ENERGY FIJI LIMITED
INVITATION TO TENDER

Supply, Installation and Commissioning Solar PV with Battery Energy Storage System (BESS)

for

12 MWac PV with BESS Project in Seaqaqa, Vanua Levu

Tender No: MR 87/2026

Invitation to Tender

Date: 12/08/2026
Tender No: MR 87/2026

Energy Fiji Limited (EFL / the “Employer") invites sealed tenders from reputable firms (the “tenderer”) for the Engineering, Procurement, and Construction (EPC) of the 12MW(AC) Solar PV Power Plant with Battery Energy Storage System (BESS) and associated facilities in Seaqaqa, Vanua Levu.

The tenderer is required to submit a tender for:

> The complete engineering design, procurement and delivery of materials and equipment, full construction and installation, testing & commissioning, and training for the PV with BESS of required capacity and associated facilities as per technical specifications, located at Seaqaqa, Vanua Levu.

All tenders for the contract shall be submitted on the appropriate tender forms provided and shall include the completed guarantees, price schedule, technical schedule and schedules of experience etc. relevant copies of which are included. The tender shall be on the basis of a lump sum contract based on firm price for the required parts, and with firm price per unit for optional extensions.

Tenderers may obtain further information from, inspect and acquire the tender documents and arrange for a site visit from:

Mr. Jitendra Reddy
The Manager, Procurement, Inventory & Supply Chain
Energy Fiji Limited
Private Mail Bag,
Suva –FIJI
Telephone: (+679) 3224360 Fax: (+679) 3311882
E-mail: tenders@efl.com.fj

There are Pre-bid meeting and site Visits planned for **26th August 2026**. All the interested tenderers are required to meet at the project site, at 11:00am. It is mandatory for a tenderer to attend the pre-bid meeting and site visit. Proof of attendance is to be attached to the bid failing which the bid is liable for rejection. Deadline for submission of tenders shall be **16:00 (local Fiji time) on Wednesday 30th September 2026**.

During evaluation of tenders EFL will invite a tenderer or tenderers for discussions, presentations and any necessary clarification before awarding of the contract.

Disclaimer

The views expressed in this Invitation to Tender (including all sections, annexes, and addendums) do not necessarily represent those of Energy Fiji Limited (EFL).

The content of this Invitation to Tender (including all sections, annexes, and addendums) offers an explanation and provides the instructions to tenderers, contract information, general and technical information, employer's requirements, concept design, schedules, and required forms. All relating to the Works to establish a solar PV power station with BESS (Battery energy storage system) and associated facilities. This Invitation to Tender is intended to provide general guidance for tenderers to prepare their tender submissions for the Works to be performed under an Engineering, Procurement and Construction (EPC) contract following the guidelines of the International Federation of Consulting Engineer (FIDIC). The information provided in this Invitation to Tender, including requirements and concept design, should be used only as a reference, and shall not be considered the final engineering design or used for the procurement and/or construction of the renewable energy system, as a detailed final design, equipment selection, and procurement shall be provided by the Tenderer under the Contract. The Tenderer is advised to perform its own due diligence and exercise its own professional judgment and to consult the relevant current building and utility regulations and standards, health & safety and environmental regulations, and other applicable guidelines as constituted in the jurisdiction of the Republic of Fiji. The Tenderer shall ensure a safe and operable system (Permanent Works), and as such adequately consult with technical manuals and data sheets from suppliers for equipment proposed and supplied under the Contract.

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Section 1

Instruction to Tenderers

1.Section 1: Instruction to Tenderers

This Invitation to Tender is conducted to allow for contracting of an EPC project, and is conducted under the framework set out in the document "Conditions of Contract for EPC/Turnkey Project", 2nd Edition 2017 (the 2017 Silver Book), published by the International Federation of Consulting Engineers (FIDIC).

It is expected as a part of this Invitation to Tender that all tenderers shall have obtained and made reference to this document when submitting a tender to the Employer. The document can be obtained (at the tenderer's expense) in both paper and electronic copy at the FIDIC website bookshop. http://fidic.org/bookshop

1. Scope of Tender
   1.1. Energy Fiji Limited (hereinafter referred to as "the Employer"), wishes to receive tenders from reputable firms or joint ventures (the "Tenderer") for Supply, Installation & Commissioning of a 12MW(AC) Solar PV with Battery Energy Storage System (BESS) in Vanua Levu as defined in these Invitation to Tender documents (hereinafter referred to as "the Works").
   1.2. The successful tenderer will be expected to complete the Works within 12 months from the Commencement Date.

2. Eligible Tenderers
   2.1. This Invitation to Tender is open to reputable firms, or joint ventures, who have the qualified experience of the Solar PV with BESS system works. For the avoidance of doubt this tender is open to tenderers who are not registered businesses in Fiji, though due to both building and electrical code requirements in Fiji, it is encouraged to include the participation of Fijian businesses and/or professionals.
   2.2. Tenderers shall provide such evidence of their continued eligibility satisfactory to the Employer as the Employer shall reasonably request.
   2.3. Tenderers shall not be under a declaration of ineligibility for corrupt or fraudulent practices in their countries of operation, or the World Bank Listing of Ineligible Firms & Individuals.
   2.4. Tenderer's net worth for the three consecutive years prior to Deadline for Submission of Bids, calculated as the difference between total assets and total liabilities, shall be positive in each financial/fiscal year.
   2.5. Participation in at least three contracts that have been successfully completed, or substantially completed in the last five years that are similar to the Works proposed in these specifications, and to IEC/Australia/New Zealand standards.
   2.6. Experience in design, integration, supply, testing and commissioning for Solar PV with BESS system (for similar equipment offered – grid stability BESS of at least 6MW/12MWh capacity using lithium-ion chemistry).

3. Eligible Materials, Equipment, and Services
   3.1. Any materials, equipment, and services to be supplied in the process of completing the Works and Contract shall have their origin from reputable companies from various countries and all expenditures made under the Contract will be limited to such Works. At the Employer's request, tenderers may be required to provide evidence of the origin of materials, equipment, and services.

   Asbestos materials, materials or insulants containing PCB's, or other materials prohibited by the laws of Fiji shall not be used in the Works.
   3.2. For purposes of 3.1 above, "services" means the Works and all project-related services including design services.
   3.3. For purposes of 3.1 above, "origin" means the place where the materials and equipment are mined, grown, produced or manufactured, and from which the services are provided.

3.4. Any materials, equipment, and services to be supplied under the Works and Contract shall not infringe or violate any industrial property or intellectual property rights or claim of any third party.

4. Qualification of the Tenderer

4.1. To be qualified for award of Contract, tenderers shall:

a) submit a written power of attorney authorizing the signatory of the tender to commit the tenderer; and

b) specify joint venture memberships, financial capability, technical capability, supply and installation facilities with comparable technical parameters, not blacklisted, and current litigation.

c) Submit proposals regarding work methods, scheduling and resourcing which shall be, provided in sufficient detail to confirm the tenderer's capability to complete the works in accordance with the specifications and the time for completion.

4.2. Tenders submitted by a joint venture of two or more firms as partners shall comply with the following requirements:

a) the tender, and in case of a successful tender, the Contract Agreement, shall be signed so as to be legally binding on all partners;

b) one of the partners shall be authorized to lead the joint venture; and this authorization shall be evidenced by submitting a power of attorney signed by legally authorized signatories of all the partners in the tender documents submitted to the Employer;

c) the partner in charge shall be authorized in writing to incur liabilities, receive payments and receive instructions for and on behalf of any or all partners of the joint venture and the entire execution of the Contract. All contract payments to be made by the Employer will be remitted to the authorized partner in charge, and it shall be their responsibility to disburse the payments to the other partners;

d) all partners of the joint venture shall be jointly and severally liable for the execution of the Contract in accordance with the Contract terms, and a relevant statement to this effect shall be included in the authorization mentioned under (b) above as well as in the Letter of Tender and the Contract Agreement (in case of a successful tender); and

e) A copy of the agreement entered into by the joint venture partners shall be submitted with the tender.

4.3. Tenderers shall also submit proposals of work methods and schedule in sufficient detail to demonstrate the adequacy of the tenderers' proposals to meet the Employer's Requirements and the completion time referred to in Clause 1.2 above.

5. One Tender per Tenderer

5.1. Each tenderer shall submit only one tender either by itself, or as a tenderer partner in a joint venture. A tenderer who submits, or participates in a joint venture, in more than one tender will cause all those tenders to be rejected. Note that suppliers / manufactures of materials and equipment for the Works are not subject to this restriction. As well firms or individuals performing third party testing or certification as required by the regulations and codes in Fiji as may be applicable are not subject to this restriction.

6. Cost of Tendering

6.1. The Tenderer shall bear all costs associated with the preparation and submission of its tender and the Employer will in no case be responsible or liable for those costs.

7. Site Visit

7.1. The Tenderer is advised to visit and examine the Site of the Works and its surroundings and obtain for itself on its own responsibility all information that may be necessary for preparing the tender and entering into the Contract with the Employer for the completion of the Works. The costs of visiting the Site shall be at the tenderer's own expense. The site can be visited on the following date and locations at:

a) The identical one-day Site visits will be scheduled on 26th August 2026 at 11:00am (local Fiji time) at the Site.

b) The Tenderer shall give notice to the Employer (person listed in the invitation to tender) of its personnel or agents attending either of the one-day Site visits, and this notice shall be given five business-days prior to the date of the Site visit on the company letterhead of the Tenderer and signed by a person having the authority for granting such representation.

7.2. The tenderer and any of its personnel or agents will be granted permission by the Employer and the Government of Fiji to enter upon the Site (its premises and lands) for the purpose of such inspection, but only upon the express condition that the tenderer, its personnel and agents, will release and indemnify the Employer and the Government of Fiji and its personnel and agents from and against all liability in respect thereof and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

8. Content of Invitation to Tender Documents

8.1. The Invitation to Tender documents are those stated below, and should be read in conjunction with any Amendment issued in accordance with Clause 10 (below):

Section 1: Instruction to Tenderers

Section 2: General Conditions of Contract

Section 3: Particular Conditions of Contract

Section 4: Employer's Requirements

Part 1: Scope of Works

Part 2: Employer's Requirements

Section 5: Forms of Tender

Section 6: Tender Schedules

Section 7: Drawings

8.2. The Tenderer is expected to examine carefully the contents of the Invitation to Tender documents. Failure to comply with the requirements of tender submission will be at the Tenderer's own risk. Pursuant to Clause 27, Tenders which are not substantially responsive to the requirements of the Invitation to Tender documents will be rejected.

9. Clarification of Invitation to Tender documents

9.1. A prospective Tenderer requiring any clarification of the Invitation to Tender documents may request a clarification of the Employer in writing by email at the Employer's email address indicated in the Invitation to Tender. Copies of the Employer's response, including a description of the inquiry, will be posted on the Employer's website for this Tender - Tender link for the Invitation to Tender (http://efl.com.fj/contractors-suppliers/tenders/).

9.2. Any clarification request of the Employer shall be submitted to the Employer at the latest fifteen (15) days prior to the deadline for submission of tenders.

10. Amendment of the Invitation to Tender Documents

10.1. At any time prior to the deadline for submission of tender, the Employer may, for any reason, whether at its own initiative or in response to a clarification requested by a prospective Tenderer, modify the bidding documents by issuing amendments. Such amendments will be issued through Addendum published on Tender ink Website.

10.2. Any amendment thus issued shall be part of the Invitation to Tender documents pursuant to Clause 9.1, and will be posted on the Employer's website for the Invitation to Tender (http://efl.com.fj/contractors-suppliers/tenders/).

10.3. To afford prospective tenders reasonable time in which to take an amendment into account in preparing their Tenders, the Employer may extend the deadline for submission of Tenders, in accordance with Clause 21.

11. Language of Tenders

11.1. The tender, and all correspondence and documents related to the Tender, exchanged between the tenderer and the Employer shall be written in the English language only. No handwritten bids will be accepted.

12. Documents Comprising the Tender

12.1. The Technical Proposal shall not contain any price, cost, commercial amount, rate, unit price, or other financial information.

Any price or financial information included in the Technical Proposal may result in the Tender being rejected as non-responsive.

12.2. The Technical Proposal shall contain the following:

- Letter of Tender signed (indicating "AVAILABLE IN FINANCIAL PROPOSAL" in the lump sum price fields, e.g. without the price indicated);
- Power of Attorney authorizing the person signing the Letter of Tender;
- Letter of Confirmation of Eligibility of the Tenderer (own statement of eligibility);
- Schedules on Qualifications of the Tenderer;
- Executive Summary of the Proposal;
- Construction Schedule;
- Schedule of Key Contractors Personnel;
- Schedule of Description of the Proposed Works (and any preliminary drawings);
- Schedule of Proposed Major Items (Completed plant technical specification including manufacturer of major items with associated documentation);
- Schedule of Tenderers Proposed Management and Timelines, including management plans;
- Tender Security: No Tender Security is required for this Tender.
- Parent Company Guarantee (if applicable);
- Legal, Technical, and Organizational information in accordance with Clause 8.1 of Section 4;
- Evidence of similar project experience in accordance with Clause 8.1 of Section 4;
- Form-A (Undertaking from Main Contractor);
- Any other materials required to be completed and submitted by Tenderers in accordance with these Instructions to Tenderers (without any costs indicated);
- Electronic version of the above documents uploaded to the appropriate **"Technical Proposal"** folder in the EFL's Online Tender Portal (only as PDF, MS Word, MS Excel, JPEG).

12.3. The Financial Proposal shall contain the following:

- Letter of Tender signed (with the price indicated);
- Schedule of Prices (including costs of optional extensions);
- Financial information in accordance with Clause 8.1 of Section 4;
- Any other materials required to be completed and submitted by Tenderers in accordance with these Instructions to Tenderers;
- Electronic version of the above documents uploaded to the appropriate **"Financial Proposal"** folder in the EFL's Online Tender Portal (only as PDF, MS Word, MS Excel, JPEG).

13. Tender Form and Schedule of Prices

13.1. The Tenderer shall complete the Letter of Tender and the appropriate Schedule of Prices furnished in the Invitation to Tender documents in the manner and detail indicated therein, following the requirements of Clause 14 and 15.

14. Tender Price

14.1. Unless specified otherwise in the Employer's Requirements, tenderers shall quote for the entire Works on a “single responsibility" basis such that the total tender price covers all the Contractor's obligations mentioned in or to be reasonably inferred from the Invitation to Tender documents in respect of the engineering, procurement, and construction of the Works. This includes any subcontracting, and the delivery, installation, test and commissioning of materials and equipment by suppliers / manufacturers. This includes all requirements under the Contractor's responsibilities for testing, pre-commissioning and commissioning of the Works and, where so required by the bidding documents, the acquisition of all permits, approvals and licenses, etc., operation & maintenance and training services, environmental management, and such other items and services as may be specified in the bidding documents, all in accordance with the requirements of the Conditions of Contract.

14.2. Tenderers shall give a breakdown of the prices in the manner and detail called for in the Schedules of Prices.

14.3. In the Schedules, Tenderers shall give the required details and a breakdown of their prices which shall include all taxes, duties, levies…etc., which are applicable in and outside of Fiji, and which apply to the delivery of the Works. In relation to prices, the following shall apply in additional to the previous sentence:

a) Design including all necessary drawings and documentation for the Work.

b) Any equipment and materials supplied from outside the Employer's country shall be quoted on DAP (previously referred to as DDU) basis to Site, including estimated ocean freight charges, local transport, insurance.

c) Civil works, installation and other services shall be quoted separately and shall include rates or prices for all labour, contractor's equipment, Temporary Works, materials, consumables and all matters and things of whatsoever nature, including local transportation, operations and maintenance services, the provision of operations and maintenance manuals, training, etc. were identified in the bidding documents, as necessary for the proper execution of the Works.

d) Mandatory spare parts and spares shall be quoted inclusive with the Plant, but clearly shown as a separate line item in pricing;

e) Recommended spare parts shall be quoted separately as specified in either subparagraph (b) or (c) above in accordance with the origin of the spare parts. It will assumed that the requested spares will be provided if not quoted.

f) Any amounts of Value Added Tax shall be indicated separately.

g) Tenderers are strongly advised to check with the Fiji Revenue & Customs Service (https://www.frcs.org.fj/), regarding employment related taxes, income tax, With Holding Tax, corporate tax, Value Added Tax, duties, and levels which may become payable in Fiji, and to make particular note of arrangements and procedures which are necessary because of the existence or non-existence of taxation agreements between Fiji and other countries. Noting incentive for renewable energy (https://www.frcs.org.fj/incentives/). Tel No. (679) 3301551 Fax No. (679) 3315537.

14.4. Prices quoted by the Tenderer shall be on a fixed lump sum basis with no forex exchange variation and shall not be adjusted for changes in the cost of labour, material or other matters except only for changes in legislation in accordance to Sub-Clause 13.6 of the General Conditions.

15. Tender Currency

15.1. Prices shall be quoted in United States Dollars (USD) for the Plant and in Fiji Dollars (FJD) for the Installation and Works.

15.2. Where prices are quoted in both a foreign currency and FJD, the Tenderer shall clearly identify the portions of the Tender Price applicable to each currency.

15.3. The Employer may require the Tenderer to provide details supporting the allocation of costs between the foreign currency and FJD.

16. Tender Validity

16.1. Tenders shall remain valid for a period of 180 days after the date of opening of Tenders specified in Clause 24.

16.2. In exceptional circumstances, prior to expiry of the original Tender validity period, the Employer may request that the Tenderers extend the period of validity for a specified additional period. The request and the responses thereto shall be made in writing or by email. A Tenderer may refuse the request without forfeiting its Tender Security. A Tenderer agreeing to the request will not be required or permitted to modify its Tender and where a Tender Security is required, shall extend the validity of its Tender Security.

17. Tender Security

17.1. No tender security required as part of the Tender submission.

18. Proposals by Tenderers

18.1. Tenderers shall submit proposals fully complying with the Employer's Requirements. Alternative or variant technical proposals shall not be permitted and will not be considered in the evaluation.

19. Format and Signing of Tender

19.1. The Tenderer shall upload the Tender's Technical Proposal to the appropriate folder in EFL's Online Tender Portal. The version uploaded in to EFL's Online Tender Portal will be considered the original. Tenderer shall upload the Tender's Financial Proposal to the appropriate folder in EFL's Online Tender Portal. The version uploaded in to EFL's Online Tender Portal will be considered the original.

19.2. The Tender shall be signed by a person or persons duly authorized to sign on behalf of the Tenderer, pursuant to Clause 4.1 (a) or 4.2 (b), as the case may be. All pages of the tender where entries or amendments have been made shall be initialed by the person or persons signing the Tender.

19.3. The Tender shall contain no alterations, omissions or additions, except those to comply with instructions issued by the Employer, or as necessary to correct errors made by the Tenderer, in which case such corrections shall be initialed by the person or persons signing the Tender.

19.4. The Tenderer shall furnish information as described in the Letter of Tender on commission or gratuities, if any, paid or to be paid relating to this Tender, and to Contract execution if the Tenderer is awarded the Contract.

20. Tender Submission

20.1. The Tenderer shall upload the Tenderer's Technical Proposal and Financial Proposal to the appropriate folder in EFL's Online Tender Portal, Tenderlink. The version uploaded in to EFL's Online Tender Portal will be considered the original.

21. Deadline for Submission of Tender

21.1. Tenders must be received by the Employer through EFL's Online Tender Portal not later than 16:00 (local Fiji time) on **30th September 2026**.

21.2. The Employer may, at its discretion, extend the deadline for submission of Tenders by issuing an addendum in accordance with Clause 10, in which case all rights and obligations of the Employer and the Tenderers previously subject to the original deadline will thereafter be subject to the deadlines extended.

22. Late Tenders

22.1. Any Tender received by the Employer after the deadline for submission of Tenders prescribed in Clause 21 will be rejected.

23. Modification and Withdrawal of Tenders

23.1. The Tenderer may modify or withdraw its Tender through the EFL Online Tender Portal at any time prior to the deadline for submission of Tenders.

23.2. No Tender may be modified or withdrawn after the deadline for submission of Tenders.

24. Opening of Tenders

24.1. The Employer shall open the Technical Proposals at the earliest suitable date and time after closing of the Tenders. The Financial Proposals shall remain unopened and in the custody of the Employer until the specified time of financial opening. If files intended for the Financial Proposal are submitted in the Technical Proposal folder, or vice versa, the Employer may reject the Tender as non-responsive.

24.2. The Employer shall open the Technical Proposals and record:

(a) the name of the Tenderer; and

(b) any other details considered appropriate by the Employer.

Only Technical Proposals opened and recorded in accordance with this Clause shall be considered for evaluation. No Tender shall be rejected at the opening of Technical Proposals except for late Tenders, in accordance with Clause 22.1.

24.3. The Employer shall prepare a record of the opening of Technical Proposals that shall include, as a minimum, the name of the Tenderer. The record shall be retained by the Employer for its own internal use and the Employer is under no obligation to disclose this to anyone.

24.4. At the end of the evaluation of the Technical Proposals, the Employer will open the Financial Proposals at the earliest suitable date and time after evaluating the Technical Proposals. Only Financial Proposals of Tenderers whose Technical Proposals have been determined to be substantially responsive shall be opened.

24.5. The Employer will notify in writing Tenderers whose Technical Proposals have been determined to be non-responsive. Their Financial Proposals shall remain unopened and shall not be considered for further evaluation.

24.6. All Financial Proposals shall be opened one at a time and the following recorded:

(a) the name of the Tenderer;
(b) the Tender Prices, including any discounts; and
(c) any other details as the Employer may consider appropriate.

Only Financial Proposals and discounts recorded during the opening of Financial Proposals shall be considered for evaluation.

24.7. The Employer shall prepare a record of the opening of Financial Proposals that shall include, as a minimum, the name of the Tenderer, the Tender Price, and any discounts. The record shall be retained by the Employer for its own internal use and the Employer is under no obligation to disclose this to anyone.

25. Process to be Confidential

25.1. Information relating to the examination, clarification, evaluation, and comparison of Tenders and recommendations for the award of a Contract shall not be disclosed to Tenderers or any other persons not officially concerned with such process. Any effort by a Tenderer to influence the Employer's processing of Tenders or award decisions may result in the rejection of the Tenderer’s Tender.

26. Clarification of Tenders and Contacting the Employer

26.1. To assist in the examination, evaluation and comparison of Tenders, the Employer may, at its sole discretion, ask any Tenderer for clarification of its Tender. The request for clarification and the response shall be in writing or email, but no change in the prices or substance of the Tender shall be sought, offered or permitted except as required to confirm the correction of arithmetic errors discovered by the Employer in the evaluation of the Tender in, accordance with Clause 28.

26.2. Subject to Clause 26.1, no Tenderer shall contact the Employer on any matter relating to its Tender from the time of the Tender opening to the time the Contract is awarded.

26.3. Any effort by the Tenderer to influence the Employer in the Employer's tender evaluation, tender comparison or Contract award decisions may result in the rejection of the Tenderer's Tender.

27. Preliminary Examination of Tenders and Determination of Responsiveness

27.1. Prior to the detailed evaluation of Tenders, the Employer will determine whether each Tender (i) has been properly signed; (iii) is accompanied by any required securities; (iv) is substantially responsive to the requirements of the tendering documents; and (v) provides any clarification and/or substantiation that the Employer may require pursuant to Clause 26.

27.2. A substantially responsive Tender is one which conforms to all the terms, conditions and requirements of the tendering documents, without material deviation or reservation. A material deviation or reservation is one (i) which affects in any substantial way the scope, quality or performance of the Works; (ii) which limits in any substantial way, inconsistent with the tendering documents, the Employer's rights or the Tenderer's obligations under the Contract; or (iii) whose rectification would affect unfairly the competitive position of other Tenderers presenting substantially responsive Tenders.

27.3. If a Tender is not substantially responsive, it will be rejected by the Employer, and may not subsequently be made responsive by correction or withdrawal of the nonconforming deviation or reservation.

28. Correction of Errors

28.1. Tenders determined to be substantially responsive will be checked by the Employer for any arithmetic errors. Arithmetic errors will be rectified on the following basis. If there is a discrepancy between the unit rate and the total cost that is obtained by multiplying the unit rate and quantity, the unit rate shall prevail and the total cost will be corrected unless in the opinion of the Employer there is an obvious misplacement of the decimal point in the unit rate, in which case the total cost as quoted will govern and the unit rate corrected. If there is a discrepancy between the total Tender amount and the sum of total costs, the sum of the total costs shall prevail and the total Tender amount will be corrected.

28.2. The amount stated in the Letter of Tender will be adjusted by the Employer in accordance with the above procedure for the correction of errors and, shall be considered as binding upon the Tenderer. If the Tenderer does not accept the corrected amount of Tender, its Tender will be rejected.

29. Evaluation and Comparison of Tenders

29.1. The Employer will evaluate and compare only the Tenders determined to be substantially responsive in accordance with Clause 27.

29.2. The Employer will carry out a detailed evaluation and scoring of the Tenders in order to reach such a determination leading to the award of the Contract, the Employer will examine the information supplied by the Tenderers and other requirements in the tendering documents, taking into account the following factors and scoring methodology.

The technical evaluation has a maximum of 75 points and represents 75% of the Final Score (relative to the highest technical score of the Tenderer with the highest ranking), and the financial evaluation has 25% of the Final score (relative to the score of the Tenderer with the lowest price bid).

The first-ranked Tender is the one that:

(i) is substantially responsive to the Tender Document, and

(ii) has the highest score of the combined technical and financial evaluation.

Only Financial Proposals of Tenderers that have successfully passed the Qualification assessment and achieved the minimum Technical Score shall be opened and evaluated.

29.2.1. Qualification (Affirmative or Not-Affirmative)

a) The determination will take into account the information provided in the Schedules on Qualifications of the Tenderer and Schedule of Key Personnel, and any annexed information to the Schedules. To include the (i) Tenderer's experience with similar projects, (ii) financial status, (iii) plans for financing the Works – without indicating

price, (iv) qualifications and experience of key personnel, and (v) the proposed Plant and/or Permanent Works meeting minimum functional guarantees; it will be based upon an examination of the documentary evidence submitted by the Tenderer, pursuant to Point 5.1, as well as such other information as the Employer deems necessary and appropriate; and an affirmative determination will be a prerequisite for the Employer to continue with the evaluation of the Tender; a negative determination will result in rejection of Tender.

29.2.2. Technical Score

a) The determination will take into account the information provided in the Schedule of Description of the Proposed Works (and any preliminary drawings), the Schedule of Proposed Major Items of Equipment, the Schedule of Tenderers Proposed Times of Milestones and Completion, and the Schedule of Contractor Health, Safety, and Environmental Management Plan, the Schedule of Deviations from Employer's Requirements, and any annexed information to the Schedules.

b) The technical score methodology is as follows:

1) Project Approach and Methodology (55 points (73%))

(i) The Technical Proposal shall include sufficient information to demonstrate a clear understanding of all the work to be carried out, including objectives, deliverables, and key challenges.

(ii) The Tenderer shall demonstrate sufficient planning to show that work will be accomplished as required and on schedule, utilizing all available resources (refer to Construction and Mobilization Schedule). The Tenderer shall demonstrate a firm understanding of the requirements and goals set forth in the scope of work, address each requirement and goal outlined in the scope of work and provide technical solutions, including site-specific adjustments, to sindicate that requirements and goals will be met on schedule. The Tenderer shall demonstrate that it understands the delivery, logistics, transportation, and shipping challenges that may be encountered during the execution of the work and will demonstrate that these challenges and risk mitigation strategies have been considered in the schedule.

(iii) Evaluation of the Tenderer's technical proposal will include an assessment of the Tenderer's technical capacity to mobilize key equipment and personnel for the contract consistent with its proposal regarding work methods, scheduling, and material sourcing in sufficient detail and fully in accordance with the requirements stipulated in Section 4 Employer's Requirements.

Evaluation will include an assessment of the Tenderer's understanding of scope and requirements, execution strategy and technical approach, logistics and supply chain management, quality management systems and certifications relevant to the project's design, construction, commissioning and its plan to ensure adherence to these quality standards and certifications.

2) Capacity Building (5 points (7%))

Plans for long-term sustainability, including technical training for Employer or authorized representatives.

Evaluation will consider:

(i) Training program,

(ii) Knowledge transfer,

(iii) Operation and maintenance capacity development,

(iv) Long-term sustainability measures.

3) Environmental, Health and Safety Management Plan (EHSMP) (15 points (20%))

Specifically, the evaluation will analyse the quality of the environmental, health and safety management plan (EHSMP). The proposal should demonstrate a

clear understanding and prioritization of the site-specific risks relating to construction health and safety and environmental and, where applicable, social and sustainable risks and how these risks will be addressed. Evaluation of the proposal from the Tenderer in going beyond the requirements for waste disposal as per the obligations and requirements set in Section 4. The evaluation will focus on the sediment and erosion control approach, minimization of traffic disruption and reduction of waste and waste footprint during all phases of the project. The maximum score may only be achieved by describing how the Tenderer will exceed the requirement.

29.2.3. Financial Score

a) Only the substantially responsive and qualified Tenders receiving a Technical Score of not less than 60 points out of 75 (80%) shall be considered for Financial Score evaluation.

b) The total Tender amount as offered in the Letter of Tender for the required capacities as defined in the Employer's Requirements, or as corrected by the Employer in accordance with Clause 28, shall be used.

c) The Financial score is evaluated using Levelized Cost of Investment (LCOI). All substantially responsive Tenders will be compared based on their evaluated tender price computed by following the criterion below for a simplified LCOI, considering 25 years of the life cycle.

LCOI value = (CAPEX) / (YIELD year-1 + YIELD year-2 +…….+ YIELD year-25)

Terms	Values
LCOI	Levelized Cost of Investment
CAPEX	A sum of total of Letter of Tender signed
YIELD in each of the 25 years	Yield based on the values presented in the Tenderer's PVsyst reports for 25 years.
BESS	For the BESS, the guaranteed output by the BESS will be used, assuming one full cycle per day up to year 15. The value provided by the Tenderers shall be checked against BoL capacity and the RTE.

29.2.4. Final Score (FS | maximum score of 100 points) is determined as follows:

$$FS = \frac{Clow}{C} X + \frac{T}{Thigh}(100 - X)$$

Where:

FS = Final Score

C = Financial Score (LCOI value)

Clow = Lowest of all Financial Score among responsive Tenders

T = Total Technical Score

Thigh = Full Technical Score = 75

X = Weight for Financial Score = 25%

29.3. Pursuant to Clause 29.2, the following evaluation methods will be followed:

29.3.1. Contractual and commercial deviations: The evaluation of contractual and commercial deviations shall be based on the evaluated cost for fulfilling the Contract in compliance with all commercial, contractual and technical obligations under the Invitation of Tender documents. Tenderers shall itemize each deviation and associated cost with each deviation. A Tenderer who submits a bid with deviations without providing an itemized

breakdown will have Technical Scores deducted for such deviations whose commercial implication is not known.

29.3.2. Time Schedule: The Works are required to be completed within the period specified in Clause 1.2. Tenderers submitting Tenders which deviate from period specified in Clause 1.2 will be penalized in the Technical Score, and deviation by more than 10% in completion time may be rejected by the Employer, as the sole Employer's discretion.

29.3.3. Functional Guarantee of the Plant and/or Permanent Works: (i) Tenderers shall state the functional guarantees (e.g. performance and efficiency) of the proposed Plant and/or Permanent Works in response to the Employer's Requirements. Plant and/or Permanent Works offered shall have a minimum (or a maximum, as the case may be) level of functional guarantees specified in the Employer's Requirements to be considered responsive. Tenderers offering Plant and/or Permanent Works with functional guarantees less (or more) than the minimum (or maximum) specified may be rejected by the Employer.

29.4. Any adjustments in price which result from the above procedures shall be added, for purposes of Comparative evaluation only, to arrive at an "Evaluated Bid Price". Bid prices quoted by Tenderers shall remain unaltered.

29.5. The Employer reserves the right to accept or reject any variation or deviation which are in excess of the requirements of the Invitation for Tender documents or otherwise result in the accrual of unsolicited benefits to the Employer shall not be taken into account in tender evaluation.

29.6. If the Tender amount stated in the Letter of Tender of the successful Tenderer is substantially below the Employer's estimate for the Contract, the Employer may require the Tenderer to produce detailed technical information and cost analyses to demonstrate the internal consistency of preliminary design and the total cost of the Works. After evaluation of the detailed technical information and cost analyses, the Employer may require that the amount of the Performance Security set forth in Clause 35 be increased at the expense of the successful Tenderer to a level sufficient to protect the Employer against financial loss in the event of default of the successful Tenderer under the Contract.

30. Domestic Preference

30.1. No preference shall be given for a domestic firm or joint venture partners.

31. Award of Contract

31.1. Subject to Clause 32, the Employer will award the Contract to the Tenderer whose Tender has been determined to be substantially responsive to the tendering documents and who has offered the Best Value for Money, e.g. the highest score as defined in Clause 29.2, provided that such Tenderer has been determined to be (i) eligible in accordance with the provisions of Clause 2; and (ii) qualified in accordance with the provisions of Clause 4.

31.2. At the discretion of the Employer, the Tenderer may be required to attend meetings at the Employer's office, and communicate in writing or electronically, for techno-commercial discussions prior to the signing of the Contract at no cost to the Employer. It is noted that these techno-commercial discussions may include the addition of Optional Capacity Extensions to Works and the Contract, which are additional to the Required Capacities. In the case of including the addition of to the Works, the Tender amount stated in the Letter of Tender shall be adjusted upwards by the cost of Optional Capacity Extensions indicated in the Schedule of Prices of the Tender and the mutually agreed upon between the Tenderer and the Employer.

32. Employer's Right to Accept any Tender, to Reject any or all Tenders

32.1. Notwithstanding Clause 31, the Employer reserves the right to accept or reject any Tender, and to annul the Invitation to Tender process and reject all Tenders, at any time prior to award of Contract, without thereby incurring any liability to the affected Tenderer or Tenderers or any obligation to inform the affected Tenderer or Tenderers of the grounds for the Employer's action.

33. Notification of Award

33.1. Prior to expiration of the period of Tender validity prescribed by the Employer, the Employer will notify the successful Tenderer by signed letter by e-mail that its Tender has been accepted. This letter (hereinafter called the "Letter of Acceptance") shall name the sum defined in the Letter of Tender which the Employer will pay the Contractor for the Required Capacities in consideration of the execution and completion the Works by the Contractor as prescribed by the Conditions of Contract.

33.2. After the issuance of the Letter of Acceptance, the sum named in the Letter of Acceptance may be adjusted in accordance with Clause 31.2 to a new sum. A signed letter (hereinafter called the “Letter of Contract Price”) will be issued by the Employer to the Tenderer by email, naming the “Contract Price” as either the sum stated in the Letter of Acceptance, or the new sum in accordance with Clause 31.2. The Contract Price shall then constitute that as defined in the Conditions of Contract.

33.3. The auction result scores and rankings of other Tenderers are not disclosed.

33.4. The notification of award will constitute the formation of the Contract.

33.5. Upon the furnishing by the successful Tenderer of a performance security, the Employer will promptly notify the other Tenderers that their Tenders have been unsuccessful.

34. Signing of Contract Agreement

34.1. Within 28 days of the Employer issuing the Letter of Contract Price to the successful Tenderer, the Employer will send the successful Tenderer the Contract Agreement provided in the Invitation to Tender documents, incorporating all agreements between the Employer and the successful Tenderer.

34.2. Within 14 days of receipt of the Contract Agreement, the successful Tenderer shall sign the Contract and return it to the Employer.

35. Performance Security

35.1. Within 28 days of the mutually signed Contract Agreement, the successful tenderer shall furnish to the Employer a Performance Security from a reputable Fijian bank in an amount equal to 10% (ten percent) of the Contract Price in accordance with the Conditions of Contract. The form of Performance Security provided in Invitation to Tender documents shall be used.

35.2. Failure of the successful Tenderer to comply with the requirements of Clause 34 or 35 shall constitute sufficient grounds for the annulment of the award and, where a Tender Security is required, the forfeiture of such Tender Security.

36. Corrupt or Fraudulent Practices

36.1. The Employer requires that the Tenderer / Contractor observe the highest standard of ethics during the procurement process under this Invitation to Tender, and the Execution of the Contract. In pursuance of this policy, the Employer defines, for the purposes of this provision, the terms set forth below as follows:

a) "Corrupt practice" means behavior on the part of officials in the public or private sectors by which they improperly and unlawfully enrich themselves and/or those close to them, or induce others to do so, by misusing the position in which they are placed, and it includes the offering, giving, receiving or soliciting of anything of value to influence the action of any such official in the procurement process or in contract execution; and

b) "Fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Employer, and includes collusive practice among tenderers (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Employer of the benefits of free and open competition;

36.2. The Employer will reject a proposal for award if it determines that the Tenderer / Contractor recommended for award has engaged in corrupt or fraudulent practices in competing for the contract in question;

36.3. Furthermore, tenderers shall be aware of the provision stated in Sub-Clauses 1.12 and 15.5 in the Conditions of Contract, and Particular Conditions Part B.

37. Governing Law

37.1. This Tender and associated works covered by the Tender are governed by the Laws of Fiji. By participating in the tender process, the Tenderer (and its holding companies, affiliates) will be taken to have accepted the application of those Laws and have submitted to the jurisdiction of the Courts of Fiji. The Tenderer must comply with all relevant Laws and approvals in preparing and submitting the Tender.

38. Insurance Requirements

38.1. The Tenderer shall provide evidence that it maintains, or is capable of obtaining and maintaining, the following minimum insurance coverages:

(i) Professional indemnity Insurance (not less than FJD 10 million);
(ii) Public and Products Liability Insurance (not less than FJD 10 million);
(iii) Workmen's Compensation Insurance in accordance with the laws of Fiji;
(iv) Contractors All Risks (CAR) Insurance for not less than 110% of the Contract Price;
(v) Marine Cargo / Transit Insurance covering transportation of Plant and Equipment to the site.

Section 2

General Conditions of Contract

2. Section 2: General Conditions of Contract

2.1 General Conditions

The General Conditions of Contract shall be the FIDIC Silver Book, 2nd Edition (2017).

For the General Conditions of Contract, the Tenderer shall refer to the "Conditions of Contract for EPC/Turnkey Project", 2nd Edition 2017 (the 2017 Silver Book), published by the International Federation of Consulting Engineers (FIDIC). The document can be obtained (at the tenderer's expense) in both paper and electronic copy at the FIDIC website bookshop. http://fidic.org/bookshop

Section 3

Particular Conditions of Contract

3. Section 3: Particular Conditions of Contract

3.1 Particular Conditions Part A – Contract Data

Contractor to fill out parts Underlined.

1.1.17.		Where the Contact allows for Cost Plus Profit, percentage profit to be added to the Cost:		Not Applicable
1.1.24.		Defects Notification Period (DNP):		365 Days
1.1.30.		The Employer's Representative:		General Manager Special Projects Energy Fiji Limited 2 Marlow Street Suva. Attention: Krishneel Prasad
1.1.76		Time for Completion		365 Days
1.3(a)(ii)		agreed methods of electronic transmission:		Email acknowledged by the receiving party (Emails are only on registered company domain emails)
1.3(d)		address of Employer for communications:		Energy Fiji Limited 2 Marlow Street, Suva, FIJI Email address of EFL representative
1.3(d)		address of Employer's Representative for communications:		Energy Fiji Limited 2 Marlow Street, Suva, FIJI Email address of EFL representative
1.3(d)		address of Contractor for communications:		Contractor to fill out Name, Company, post address, email address
1.4		Contract shall be governed by the law of:		Republic of Fiji
1.4		ruling language		English
1.4		language for communications:		English
1.8		number of additional paper copies of Contractor's Documents,		One copy
1.14		total liability of the Contractor to the Employer under or in connection with the Contract.		110% (One Hundred and Ten Percent) of the Contract Price in the currencies and proportions in which Contract Price is payable

2.1		After the Contract comes into full force and effect, the Contractor shall be given right of access to all or part of the Site within		14 days from the Commencement Date
2.4		Employer's financial arrangements		The Employer's financial arrangements for payment of the Contract price are funded through EFL's internal funds.
3,2		Other Employer's Personnel		National Thermal Power Corporation, NTPC Bhawan, Scope Complex, 7, Institutional Area, Lodi Road, New Delhi - 110003, India
4.2		Performance Security (as percentages of the Contract Price in Currencies):		10 % of Contract Price In the currencies and proportions in which the Contract Price is payable [*Fill out the value of the Performance Security in numbers and writing after award*]
4.4(a)		maximum allowable accumulated value of work subcontracted (as a percentage of the Contract Price)		Up to 30 % and only in the following: • Local manpower/labour component associated with Civil Works only, • Local subcontractors for vegetation clearing, topographic survey, soil investigations, logistics and transportation all the above subject to the prior written approval of the Employer
4.4(b)		parts of the Works for which subcontracting is not permitted.		Project Management Any Part of Design, Calculation and Documentation Supervision on Site for the entire Duration of the Works, including Defects Notification Period Training & Commissioning (except if performed by equipment supplier)
4.4		(i) Subcontractors for which the Contractor shall give Notice before appointment (ii) Subcontractors for which the Contractor shall give Notice before commencement of work (iii) Subcontractors for which the Contractor shall give Notice before commencement of work on Site		(i) Community outreach (ii) Installation Works, Testing & Survey (iii) Civil works Mechanical & Electrical works
4.19		period of payment for temporary utilities		The Contractor shall be responsible for all temporary utilities. Temporary utility works shall include all utilities required for construction, including potable water supply, sanitary facilities, toilets and other temporary facilities required for the execution of the Works. Such

<table>
<tr><td></td><td></td><td></td><td></td><td>facilities shall be installed, operated and maintained in accordance with all applicable laws and regulations.</td></tr>
<tr><td>4.20</td><td></td><td>number of additional paper copies of progress reports.</td><td></td><td>Three copies</td></tr>
<tr><td>6.5</td><td></td><td>normal working hours on the Site</td><td></td><td>07:00 to 17:00, and as per Department of Environment approval conditions.</td></tr>
<tr><td>6.9A</td><td></td><td>Key Personnel</td><td></td><td>(1) Project Manager [Contractor to insert name]
(2) Construction Superintendent [Contractor to insert name]
(3) Design Manager [Contractor to insert name]</td></tr>
<tr><td>8.3</td><td></td><td>number of additional paper copies of programmes</td><td></td><td>Three copies</td></tr>
<tr><td>8.2A</td><td></td><td>Milestone Schedule</td><td></td><td>
<table>
<tr><td>Milestone</td><td>Due Date</td><td></td></tr>
<tr><td>Submission of Issued for Construction Drawings</td><td>No later than 140 days from Commencement Date</td><td></td></tr>
<tr><td>Completion of Installation of Major Plant (Solar Panels, Inverters, Battery Energy Storage System, Switchgears, All cables)</td><td>No later than 300 days from Commencement Date</td><td></td></tr>
<tr><td>Commencement of Testing on Completion</td><td>No later than 315 days from Commencement Date</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>8.7A</td><td></td><td>Delay Damages payable for each day of delay for failing to achieve a milestone as per milestone schedule</td><td></td><td>0.05% of the Contract price per each Calendar day</td></tr>
<tr><td>8.7A</td><td></td><td>Maximum amount of delay damages associated with Milestones</td><td></td><td>1% per milestone</td></tr>
<tr><td>8.8</td><td></td><td>Delay Damages payable for each day of delay.</td><td></td><td>0.5% of the Contract Price per each calendar day</td></tr>
<tr><td>8.8</td><td></td><td>maximum amount of Delay Damages</td><td></td><td>10% of the Contract Price</td></tr>
<tr><td>13.4(b)(ii)</td><td></td><td>percentage rate to be applied to Provisional Sums for overhead charges and profit</td><td></td><td>5%</td></tr>
</table>

<table>
<tr><td>14.2</td><td></td><td>total amount of Advance Payment (as a percentage of the final Contract Price)</td><td></td><td>Contractor to Propose, not to be more than 10% of Contract Price and subject to provision of by the Contractor of an Advance Payment Guarantee from a Bank in Fiji, which shall remain valid (full sum) and irrevocable until the Taking Over Certificate is issued.</td></tr>
<tr><td>14.2</td><td></td><td>currency or currencies of Advance Payment</td><td></td><td>Same as Contract Price</td></tr>
<tr><td>14.2.3</td><td></td><td>percentage deductions for the repayment of the Advance Payment</td><td></td><td>Nil</td></tr>
<tr><td>14.3</td><td></td><td>period of payment</td><td></td><td>30 days</td></tr>
<tr><td>14.3(b)</td><td></td><td>number of additional paper copies of Statements,</td><td></td><td>One copy</td></tr>
<tr><td>14.3(ii)</td><td></td><td>percentage of retention</td><td></td><td>10%</td></tr>
<tr><td>14.3(iii)</td><td></td><td>limit of Retention Money
(as a percentage of Contract Price)</td><td></td><td>10%</td></tr>
<tr><td>14.4</td><td></td><td>The schedule of payments</td><td></td><td>The Payment milestones for Plant (off-shore Plant) shall be as follows:
<table>
<tr><th>Milestone</th><th>Indicative % of Contract Price</th></tr>
<tr><td>Advance payment (against Advance Payment Bank Guarantee)</td><td>(Max) 10%</td></tr>
<tr><td>Approval of detailed engineering drawings</td><td>15%</td></tr>
<tr><td>Completion of Factory Acceptance Tests and Dispatch of Plant with copy of Bill of Lading</td><td>25%</td></tr>
<tr><td>Delivery of Plant to the site</td><td>10%</td></tr>
<tr><td>Completion of installation / mechanical-electrical completion</td><td>15%</td></tr>
<tr><td>Provisional Acceptance Certificate (PAC) / successful commissioning of Plant to the Grid</td><td>15%</td></tr>
<tr><td>Retention Sum, 50% of which becomes available for release upon issue of Taking Over Certificate, and other 50% upon release of Performance Certificate by the Employer</td><td>10%</td></tr>
</table>
The Payment milestones for the on-shore portion (Materials and Works) shall be based on progressive accumulation of the Works,
<table>
<tr><th>Milestone</th><th>Indicative % of Contract Price</th></tr>
<tr><td>Installation Services and Works, including material procurement in Fiji, based on progress claim</td><td>Up to 90%</td></tr>
</table></td></tr>
</table>

				Retention Sum, 50% of which becomes available for release upon issue of Taking Over Certificate, and other 50% upon release of Performance Certificate by the Employer: 10%
14.5(b)(i)		Plant and Materials for payment when shipped.		Refer Clause 14.4
14.5(c)(i)		Plant and Materials for payment when delivered to the Site		Refer Clause 14.4
14.6.2		minimum amount of interim payment.		FJD 550,000 (or equivalent in currency of bid)
14.7(b)(i)		period for the Employer to make interim payments to the Contractor under Sub-Clause 14.6 [Interim Payment].		56 days
14.7(b)(ii)		period for the Employer to make interim payments to the Contractor under Sub-Clause 14.13 [Final Payment]		42 days
14.7(c)		period for the Employer to make final payment to the Contractor		56 days
14.8		financing charges for delayed payment (percentage points above the average Reserve Bank of Fiji short-term lending rate % as referred to under sub-paragraph (a)).		0%
14.11.1(b)		number of additional paper copies of draft Final Statement.		One copy
14.15		currencies for payment of Contract Price.		*[Tenderer to fill and to be finalized]*
14.15(a)(i)		portions or amounts of Local and Foreign Currencies are: Local Foreign		Not Applicable
14.15(c)		Currencies and proportions for payment of Delay Damages.		In the same currencies as Contract Price

14.15(g)		Rates of exchange		Not applicable
17.2(d)		forces of nature, the risks of which are allocated to the Contractor		Tropical storms Tropical cyclones Sea surges
19.1		Permitted deductible limits: insurance required for the Works insurance required for Goods insurance required for liability for breach of professional duty, insurance required against liability for fitness for purpose (if any is required). insurance required for injury to persons and damage to property. insurance required for injury to employees other insurances required by Laws and by local practice: _____ _____		Contractor to fill out the values, will be subject to Employer agreement.
19.2(1)(b)		additional amount to be insured (as a percentage of the replacement value, if less or more than 15%)		15%
19.2(1)(iv)		List of Exceptional Risks which shall not be excluded from the insurance cover for the Works		Tropical storms Tropical cyclones Sea surges
19.2.2		extent of insurance required for Goods, amount of insurance required for Goods.		Full value of Goods
19.2.3(a)		amount of insurance required for liability for breach of professional duty		Contractor to fill out the value of the Contract Price in numbers and writing after award
19.2.3(b)		insurance required against liability for fitness for purpose		Yes
19.2.3		period of insurance required for liability for		1096 Days from the Commencement Date.

		breach of professional duty		
19.2.4		amount of insurance required for injury to persons and damage to property		Contractor to fill out the their insured amount but not less than USD 5,000,000 for personal injury and USD 5,000,000 for damage to property
19.2.6		other insurances required by Laws and by local practice		As applicable in the Fiji for construction projects
21.1		time for appointment of DAAB		28 days
21.1		the DAAB shall comprise		3 members
21.1		list of proposed members of DAAB proposed by Employer proposed by Contractor		To be proposed by the Employer and Contractor upon written notice of a dispute
21.2		Appointing entity (official) for DAAB members		

3.2 Particular Conditions Part B – Special Provisions

Sub-Clause 1.1	Insert two new definitions under Sub-Clause 1.1: "" "**Milestone**" means a part of the Plant and/or a part of the Works stated in the Contract Data (if any), and described in detail in the Employer's Requirements as a Milestone, which is to be completed by the time for completion stated in Sub-Clause 4.24 [*Milestone Works*] but is not to be taken over by the Employer after completion. "**Milestone Certificate**" means the certificate issued by the Employer's Representative under Sub-Clause 4.24 [*Milestones*]."
Sub-Clause 1.13	Add to Sub-Clause 1.13 the following: "Without limitation to its obligations under the Contract, the Contractor shall comply with all applicable Laws of the Country relating to the design, review, certification, approval, construction, testing, commissioning and completion of the Works. The Contractor shall obtain, maintain and comply with all permits, licences, consents, approvals, clearances, certifications, registrations and statutory authorisations required for the execution and completion of the Works, except for those expressly stated in the Contract to be the responsibility of the Employer. Where applicable Laws or any authority having jurisdiction require design documents, calculations, drawings, specifications, reports or submissions to be reviewed, certified, endorsed or signed by a Registered Professional Engineer, Chartered Professional Engineer, Licensed Engineer, Independent Reviewer or other qualified professional, the Contractor shall procure such review, certification, endorsement or sign-off and shall provide copies thereof to the Employer. The Contractor shall promptly notify the Employer of any requirement imposed by a Statutory Authority that may affect the design, scope, quality, programme or cost of the Works and shall submit proposals for compliance where required. The Contractor shall be deemed to have allowed in the Accepted Contract Amount and the Time for Completion for compliance with all statutory approval, certification and professional sign-off requirements existing as at the Base Date. Neither any approval, acceptance, review, certification, inspection or sign-off by the Employer, any Statutory Authority or any professional reviewer shall relieve the Contractor of any obligation, liability or responsibility under the Contract."
Sub-clause 3.1	Add to Sub-clause 3.1 the following:

	"The Employer's Representative shall obtain the specific approval of the Employer before taking action under the following clauses of the General Conditions. (a) approving sub-contracting of any part of the Works under Sub-Clause 4.4. (b) certifying additional cost to the Contract Price. (c) granting an extension of time for completion under Sub-Clause 8.5. (d) suspending progress of part or all of the Works under Sub-Clause 8.10. (e) issuing a variation under Clause 13. (f) issuing Taking-Over Certificate for the whole of the Works under Sub-Clause 10.1. (g) issuing Performance Certificate for the Works under Sub-Clause 11.9. (h) Before commencing the work, prepare the drawings for construction and obtain the approval of the employer, and carry out the construction. (i) Manufacture of equipment and materials shall commence only after the relevant drawings and documents have been reviewed and approved for manufacture by the Employer. (All materials must be packed and stored on site before delivery and storage to avoid damage during transportation and storage.) Notwithstanding the obligation to obtain approval as set out above, if in the opinion of the Employer's Representative, an emergency occurs affecting the safety of life or of the Works or of adjoining property, it may, without relieving the Contractor of any of its duties and responsibilities under the Contract, instruct the Contractor to execute all such work or to do all such things as may, in the opinion of the Employer's Representative be necessary to abate or reduce the risk. The Contractor shall forthwith comply with the instructions of the Employer's Representative despite the absence of approval of the Employer. The Employer's Representative shall determine the extra cost to the Contractor for carrying out of such instruction and obtain the Employer's approval for an addition to the Contract Price."
Sub-Clause 4.1	Add the following sentence to precede the existing text under Sub-Clause 4.1: "The Contractor shall provide the Design in accordance with Clause 5."
Sub-Clause 4.2.1	Replace the first paragraph of Sub-Clause 4.2.1 with: "The Contractor shall deliver the Performance Security to the Employer within 28 days after both Parties have signed the Contract Agreement. The Performance Security shall be in the form of a bank guarantee from a commercial bank and not Financial Service Institution, issued either (a) by a bank located in the country of the Employer or a foreign commercial bank through a correspondent bank located in the country of the Employer, or (b) directly by a foreign bank acceptable to the Employer. The performance security shall be denominated in the types and proportions of currencies in which the Contract Price is payable. When providing such security to the Employer, the Contractor shall notify the Employer's Representative of so doing."
Sub-Clause 4.4	The following shall be added to Sub-Clause 4.4:

	"The subcontractors identified in the Contractor's Tender and listed in its Bid are designated as Key Subcontractors. The Contractor shall not replace any Key Subcontractor without the prior written consent of the Employer. Any proposed replacement shall possess qualifications, experience, personnel, equipment and financial capability at least equivalent to those of the original Key Subcontractor. The Contractor shall provide full supporting information for the Employer's review."
Sub-Clause 4.20	The following shall be added to Sub-Clause 4.20: In addition, the Contractor shall provide to the Employer's Representative, "Weekly Status Update Reports" on a weekly basis, of 2 to 4 pages in length. Which proves an update to the progress made in the completion of the Works, from the period ending in the previous week's report.
Sub-Clause 4.24	Add new Sub-Clause 4.24 "Milestones" "If no Milestones are specified in the Contract Data, this Sub-Clause shall not apply. The Contractor shall complete the works of each Milestone (including all work which is stated in the Employer's Requirements as being required for the Milestone to be considered complete) within the time for completion of the Milestone, as stated in the Contract Data, calculated from the Commencement Date. The Contractor shall include, in the initial programme and each revised programme, under sub-paragraph (a) of Sub-Clause 8.3 [*Programme*], the time for completion for each Milestone. Sub-paragraph (d) of Sub-Clause 8.4 [*Advance Warning*] and Sub-Clause 8.5 [*Extension of the Time for Completion*] shall apply to each Milestone, such that "Time for Completion" under Sub-Clause 8.5 shall be read as the time for completion of a Milestone under this Sub-Clause. The Contractor may apply, by Notice to the Employer's Representative, for a Milestone Certificate not earlier than 14 days before the works of a Milestone will, in the Contractor's opinion, be complete. The Employer's Representative shall, within 28 days after receiving the Contractor's Notice: a) issue the Milestone Certificate to the Contractor, stating the date on which the works of the Milestone were completed in accordance with the Contract, except for any minor outstanding work and defects (as shall be listed in the Milestone Certificate); or b) reject the application, giving reasons and specifying the work required to be done and defects required to be remedied by the Contractor to enable the Milestone Certificate to be issued. The Contractor shall then complete the work referred to in sub-paragraph (b) of this Sub-Clause before issuing a further Notice of application under this Sub-Clause. If the Employer's Representative fails either to issue the Milestone Certificate or to reject the Contractor's application within the above period of 28 days, and if the works of a Milestone are complete in

	accordance with the Contract, the Milestone Certificate shall be deemed to have been issued on the date which is 14 days after the date stated in the Contractor's Notice of application. If Delay Damages for a Milestone are stated in the Contract Data, and if the Contractor fails to complete the works of the Milestone within the time for completion of the Milestone (with any extension under this Sub-Clause): (i) the Contractor shall, subject to Sub-Clause 20.1 [*Claims*], pay Delay Damages to the Employer for this default; (ii) such Delay Damages shall be the amount stated in the Contract Data, for every day which shall elapse between the time for completion for the Milestone (with any extension under this Sub-Clause) and the date stated in the Milestone Certificate; (iii) these Delay Damages shall be the only damages due from the Contractor for such default; and (iv) the total amount of Delay Damages for all Milestones shall not exceed the maximum amount stated in the Contract Data (this shall not limit the Contractor's liability for Delay Damages in any case of fraud, gross negligence, deliberate default or reckless misconduct by the Contractor)."
Sub-Clause 5.1	The following shall be omitted from Sub-Clause 5.1: "(d) portions, data and information which cannot be verified by the Contractor, except as otherwise stated in the Contract." The following shall be added to Sub-Clause 5.1: "The Contractor shall obtain and maintain all design certifications, professional endorsements, authority approvals and statutory sign-offs required for the design, construction, testing, commissioning and operation of the Works. The cost and time associated with obtaining such approvals shall be deemed included in the Accepted Contract Amount and Time for Completion unless otherwise stated in the Contract." Add the following to Sub-clause 5.1: "The Contractor shall design the Works so that the Works, when constructed, completed, tested, commissioned and operated in accordance with the Contract, will achieve the Performance Guarantees stated in Schedule [2] (Performance Guarantees). The Contractor warrants that all Contractor's Documents, calculations, specifications, drawings and design submissions have been prepared on the basis that the Works will satisfy the Performance Guarantees. The Contractor shall be responsible for verifying that all design criteria, equipment selections, process parameters, operating assumptions and engineering calculations are sufficient to achieve the Performance Guarantees.

	Where any Contractor's Document contains assumptions relevant to the achievement of a Performance Guarantee, such assumptions shall be clearly identified and substantiated by engineering analysis acceptable to the Employer. Compliance of any Contractor's Document with the Employer's Requirements or the issue of a Notice of No-Objection by the Employer shall not constitute acceptance that the design will achieve the Performance Guarantees and shall not relieve the Contractor of responsibility for achieving them.
Sub-Clause 5.2	The following shall be added to 5.2.1, under Sub-Clause 5.2: “Each Contractor's Document submitted for review shall identify the applicable Performance Guarantee(s) to which the document relates and shall demonstrate how the proposed design satisfies the relevant Performance Guarantee requirements. Achievement of the Performance Guarantees shall be demonstrated by the Tests on Completion and, where applicable, the Tests after Completion specified in the Contract. The Contractor acknowledges that acceptance of Contractor's Documents does not modify, reduce or replace the Performance Guarantees.” The following shall be added to 5.2.2, under Sub-clause 5.2: “The Employer may require the Contractor to provide calculations, models, simulations, process studies, equipment performance curves, manufacturer's data, energy balance calculations, hydraulic calculations and other supporting information to demonstrate achievement of the Performance Guarantees. If the Employer considers that a Contractor's Document does not adequately demonstrate compliance with a Performance Guarantee, the Employer may notify the Contractor that the Contractor's Document fails to comply with the Contract. Any Notice of No-Objection issued by the Employer shall not be taken as verification of any calculation, model, simulation, assumption or analysis relating to Performance Guarantees and shall not relieve the Contractor of responsibility for achieving the Performance Guarantees. Notwithstanding any No-Objection given by the Employer, any Contractor's Document which by applicable Laws, regulations, codes, permits or approvals requires review, certification, endorsement or approval by a statutory authority, local authority, utility provider, licensed professional engineer, independent certifier or other governmental body shall also be submitted to such authority or person for review and approval. The Contractor shall submit copies of all such approvals, certifications, endorsements and sign-offs to the Employer promptly upon receipt.

	The Contractor shall obtain all such approvals, certifications, endorsements and sign-offs required for the design, construction, commissioning and operation of the Works unless otherwise stated in the Employer's Requirements. No Objection by the Employer shall not constitute, replace or be deemed to be any statutory approval or professional certification required under applicable Laws and/or Regulations. The Contractor shall remain fully responsible for the adequacy of the design and compliance with all applicable Laws, regulations, standards and approval requirements notwithstanding any review, No-Objection, certification, endorsement or approval by the Employer, any authority or any professional reviewer. Delays arising from the review of Contractor's Documents by statutory authorities shall be deemed included in the Time for Completion except to the extent that such delay results from an unforeseeable change in Law, delay attributable to the Employer, or a delay caused by a public authority acting contrary to the applicable Laws." Add the following under Sub-Clause 5.2, after the last paragraph in 5.2.3: "5.2.4 <u>Performance Compliance Register</u> The Contractor shall maintain a Performance Compliance Register which shall identify: a. each Performance Guarantee; b. the design criteria supporting such Performance Guarantee; c. the design documents demonstrating compliance; d. the calculations supporting compliance; e. the testing procedure by which compliance will be verified. The Register shall be submitted and updated with each design submission."
Sub-Clause 6.9A	Add Sub-Clause 6.9A "Key Personnel": "The Contractor shall appoint and maintain throughout the execution of the Works the Key Personnel identified in the Employer's Requirements. Each Key Person shall possess the qualifications, professional registrations, certifications and experience specified in the Employer's Requirements. The Contractor shall not remove, replace or reassign any Key Person without the prior consent of the Employer, such consent not to be unreasonably withheld. Any replacement Key Person shall possess qualifications and experience equal to or better than those of the person being replaced and shall be subject to the Employer's prior review and acceptance. The Project Manager shall be the Contractor's Representative for the purposes of Sub-Clause 4.3 and shall have full authority to receive instructions and make binding decisions on behalf of the Contractor.

	The Employer may withhold certification of payments relating to Preliminaries, Site Management Costs or Time-Related Charges for any period during which the Contractor fails to provide the required Key Personnel. No payment shall be due for the costs of any Key Person unless such Key Person satisfies the requirements of the Contract. The Project Manager shall be present in the Country for the duration of the Works except during approved leave periods. The Contractor acknowledges that the qualifications and experience of the Key Personnel submitted with the Contractor's Tender formed part of the basis upon which the Contract was awarded. Failure to maintain the Key Personnel required under the Contract may constitute a failure to proceed with the Works with due expedition and competence. Failure to provide and maintain an approved Project Manager shall entitle the Employer to apply Performance Deductions of FJD 2,000 per day until a compliant replacement has been mobilised and is available on site. Failure to provide and maintain an approved Site Superintendent shall entitle the Employer to apply Performance Deductions of FJD 1,000 per day. Failure to provide or maintain required Key Personnel shall be a failure to comply with the Contract and may result in a Notice to Correct under Sub-Clause 15.1. The Employer may issue a Notice to Correct requiring replacement or mobilisation of compliant personnel within a specified period. Failure to provide a compliant replacement within 28 days after receipt of a Notice to Correct shall constitute a material breach of the Contract."
Sub-Clause 6.13	Add Sub-Clause 6.13 "Foreign Personnel" "The Contractor may bring into the Country any foreign personnel who are necessary for the execution of the Works to the extent allowed by the applicable Laws. The Contractor shall ensure that these personnel are provided with the required visas and work permits. The Contractor shall be responsible for the return of these personnel to the place where they were recruited or to their domicile. In the event of the death in the Country of any of these personnel or members of their families, the Contractor shall similarly be responsible for making the appropriate arrangements for their return or burial."
Sub-Clause 6.14	Add Sub-Clause 6.14 "Festivals and Religious Customs": "The Contractor shall respect the Country's recognised festivals, days of rest and religious or other customs."
Sub-Clause 6.15	Add Sub-Clause 6.15 "Forced Labour"" "The Contractor shall not employ forced labour, which consists of any work or service, not voluntarily performed, that is exacted from an individual under threat of force or penalty, and includes any kind of involuntary or compulsory labour, such as indentured labour, bonded labour or similar labour-contracting arrangements."

Sub-Clause 6.16	Add Sub-Clause 6.16 “Employment Records of Workers”: “The Contractor shall keep complete and accurate records of the employment of personnel and labour at the Site. The records shall include the names, ages, genders, hours worked and wages paid to all workers. These records shall be summarised on a monthly basis and submitted to the Employer’s Representative. These records shall be included in the details to be submitted by the Contractor under Sub-Clause 6.10 [*Contractor’s Records*].”
Sub-Clause 6.17	Add Sub-Clause 6.17 “Measures against Insect & Pest Nuisance”: "The Contractor shall at all times take the necessary precautions to protect all staff and labour employed on the Site from insect and pest nuisance, and to reduce the dangers to health and the general nuisance occasioned by the same. The Contractor shall provide its staff and labour with suitable prophylactics for the prevention of malaria and dengue fever and take steps to prevent the formation of stagnant pools of water. The Contractor shall comply with all the regulations of the local health authorities and shall arrange to spray thoroughly with approved insecticide all buildings erected on the Site. Such treatment shall be carried out at least once a year or as instructed by such authorities."
Sub-clause 6.18	Add Sub-Clause 6.18 “Epidemics” "In the event of any outbreak of illness of an epidemic nature, the Contractor shall comply with and carry out such regulations, orders and requirements as may be made by the Government or the local medical or sanitary authorities, for the purpose of dealing and overcoming the same."
Sub-clause 6.19	Add Sub-Clause 6.19 “Alcoholic Liqueurs or Drugs” "The Contractor shall not import, sell, give, barter or otherwise dispose of any alcoholic liquor or drugs, or permit or suffer any such importation, sale, gift, barter or disposal by his Subcontractors, agents staff or labour."
Sub-clause 6.20	Add Sub-Clause 6.20 “Arms and Ammunition” "The Contractor shall not give, barter or otherwise dispose of to any person or persons, any arms or ammunition of any kind or permit or suffer to the same as aforesaid.”
Sub-clause 6.21	Add Sub-Clause 6.21 “Burial of the Dead” “The Contractor shall make all necessary arrangements for the transport, to any place as required for burial, of any of his expatriate employees or members of their families who may die in the Country. The Contractor shall also be responsible, to the extent required by local regulations, for making any arrangements with regard to burial of any of his local employees who may die while engaged upon the Works.”
Sub-Clause 6.22	Add Sub-Clause 6.22 “Corrupt or Fraudulent Practices”: “The Employer requires that the Contractor observe the highest standard of ethics during the procurement process under the Invitation

	to Tender, and the execution of the Contract. In pursuance of this policy, the Employer defines, for the purposes of this provision, the terms set forth below as follows: (a) "corrupt practice" means behavior on the part of officials in the public or private sectors by which they improperly and unlawfully enrich themselves and/or those close to them, or induce others to do so, by misusing the position in which they are placed, and it includes the offering, giving, receiving or soliciting of anything of value to influence the action of any such official in the procurement process or in contract execution; and (b) "fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Employer, and includes collusive practice among bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Employer of the benefits of free and open competition. If in the judgment of the Employer the Contractor has engaged in corrupt or fraudulent practices, the Employer may, after having given 14 days' notice to the Contractor, terminate the Contractor's employment under the Contract and expel the Contractor from the Site, and the provisions of Clause 15 shall apply as if such expulsion had been made under Sub-Clause 15.2."
Sub-Clause 7.9	Add Sub-Clause 7.9 "Restriction on Eligibility": "Any materials, equipment, services or design services which will be incorporated in or required for the Contract, as well as the Contractor's Equipment and other supplies, shall have their origin from reputable source countries acceptable to the Employer. (b) For the purpose of this clause, "services" means the Works and all project-related services including Design services. (c) For the purposes of this clause, "origin" means the place where the materials and equipment were mined, grown, produced, or manufactured, or from which the services are provided. (d) The origin of Goods and Services is distinct from the nationality of the Supplier."
Sub-Clause 8.2A	Add Sub-Clause 8.2A "Milestones" "The Contractor shall achieve each Milestone by the relevant Milestone Date stated in the Contract Data. The Contractor shall organise and execute the design, procurement, construction and all related activities so as to achieve each Milestone by its Milestone Date. Achievement of a Milestone shall occur only when the relevant activity, approval, certification, permit, submission or completion event identified in the Milestone Schedule has been fully achieved and accepted where applicable."
Sub-Clause 8.7A	Add Sub-Clause 8.7A "Delay Damages for Failure to Achieve Milestones"

	"If the Contractor fails to achieve any Milestone by the relevant Milestone Date stated in the Contract Data, the Contractor shall pay Delay Damages to the Employer for each day from the day after the applicable Milestone Date until the relevant Milestone is achieved. The payment of Delay Damages for a Milestone shall not relieve the Contractor from its obligation to achieve the Milestone or any subsequent Milestone. Delay Damages for a Milestone shall accrue independently of any Delay Damages for failure to achieve Completion of the Works. The aggregate amount of Delay Damages payable under this Sub-Clause shall not exceed the maximum percentage stated in the Contract Data."
Schedule 9.1A	Add Sub-Clause 9.1A "Performance Guarantees": The Contractor guarantees that upon Completion and during the Tests on Completion the Works shall achieve the Performance Guarantees set out in Schedule 1 (Performance Guarantees). Failure to achieve any Performance Guarantee shall constitute a failure to pass the relevant Test on Completion unless otherwise provided in the Contract.
Sub-Clause 9.4A	Add Sub-Clause 9.4A "Performance Damages": If the Works fail to achieve any Performance Guarantee stated in Schedule 1, but the Employer elects to take over the Works, the Contractor shall pay Performance Damages calculated in accordance with Schedule 1. Payment of Performance Damages shall be in full satisfaction of the failure to achieve the relevant Performance Guarantee. The aggregate liability for Performance Damages shall not exceed 10% of the Accepted Contract Amount.
Sub-clause 11.9	Amend Sub-Clause 11.9 as follows: Replace " (b) completed and tested all the Works (including remedying any defects) in accordance with the Contract" With "(b) completed and tested all the Works (including remedying any defects) in accordance with the Contract, including the completion of Tests After Completion and certification of compliance with the Performance Gurantees."
Sub-Clause 12.1A	Add Sub-Clause 12.1A "Performance Guarantees":

	"The Contractor guarantees that the Works shall achieve the Performance Guarantees specified in Schedule 2 (Performance Guarantees) during the Tests after Completion. The Contractor shall demonstrate compliance with the Performance Guarantees in accordance with the procedures stated in Schedule 2 (Tests after Completion Procedures). Failure to achieve a Performance Guarantee shall constitute a failure of the relevant Test after Completion."
Sub-Clause 12.4A	Add Sub-clause 12.14A "Performance Damages": "If the Works fail to achieve any Performance Guarantee specified in Schedule 1, and the Employer elects to retain the Works, the Contractor shall pay Performance Damages calculated in accordance with Schedule 1. Performance Damages shall be deducted from monies due to the Contractor or recovered as a debt. Payment of Performance Damages shall not relieve the Contractor from any obligation to remedy defects or to comply with any minimum performance requirements specified in the Contract."
Sub-Clause 12.4B	Add Sub-clause 12.4B "Re-Testing": "If the Works fail any Test after Completion, the Contractor may, at its own cost, undertake remedial measures and repeat the Test within a period agreed by the Parties. The Employer may require not more than two additional retests unless otherwise agreed."
Sub-clause 14.1	Add to Sub-clause 14.1 the following: "(d) The Contract Price shall include all taxes, duties and other charges imposed outside the Employer's country on the production, manufacture, sale and transport of the Contractor's equipment, Plant, materials and supplies to be used on or furnished under the Contract, and on the services performance under the Contract. (e) The Contract Price shall include all costs and charges associated with clearing, and delivery to site in Fiji, but shall exclude import duties and associated Value Added Tax. Any other taxies, such as with-holding Tax, business taxes, income and other taxes that may be levied in accordance to the laws and regulations in being as of the date 28 days prior to the closing date for submission of bids in the Employer's country on the Contractor's Equipment, Plant, materials and supplies (permanent, temporary and consumable) acquired for the purpose of the Contract and on the services performed under the Contract shall be included in the Contract Price. Nothing in the Contract shall relieve the Contractor from its responsibility to pay any

	tax that may be levied in the Employer's country on profits made by it in respect of the Contract." (f) The Contractor shall pay for all clearing, handling charges, port dues and demurrage. (g) Customs and import duties if any in respect of the Contractor's Equipment shall be borne by the Contractor. (h) Notwithstanding Sub Clauses 14.1 (d) through 14.1 (g) above, the Contractor shall ensure that all customs and import duties and taxes are paid on time. For the avoidance of doubt the Contractor shall not be entitled to any extension of time as a result of any delayed payments of import duties and taxes which was within its control."
General	Any costs for guarantees, bonds, or securities under the Tender and Contract shall be borne by the Contractor.

3.2.1 Schedule 1: Performance Guarantees

Functional Guarantee	Min. Requirements	Guaranteed by Contractor
Solar Plant		
Plant DC Capacity		
Performance Ratio (PR)	85%	
Plant AC capacity		
Availability	95%	
BESS		
Battery size (BOL)		
Battery round trip efficiency (RTE)	90%	
Battery SOH	100%	

Note: Details of the Performance Guarantee will be provided in a subsequent revision of the tender documents.

3.2.2 Schedule 2: Performance Damages

Note: Details of the Performance Damages will be provided in a subsequent revision of the tender documents.

Section 4

Employer's Requirements

SCOPE OF WORK, TECHNICAL SPECIFICATIONS & SCHEDULES

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1. PROJECT INFORMATION

1.1 INTRODUCTION

Energy Fiji Limited (EFL) proposes to develop a **12 MWAC grid-connected ground-mounted Solar Photovoltaic Power Plant integrated with a 6 MW/12 MWh Battery Energy Storage System (BESS) at Seaqaqa, Vanua Levu, Fiji**. EFL is responsible for providing and maintaining an efficient, cost-effective, safe, secure and reliable electricity supply in Fiji. The proposed Project supports EFL's objective of increasing renewable energy generation and modernising Fiji's electricity network.

The Project shall be implemented as a turnkey basis for **Engineering, Procurement and Construction (EPC) Package** through a competitive bidding process. The EPC Contractor shall be responsible for the Site surveys, Site & GRID related studies, complete design, engineering, procurement, manufacture, inspection, testing, Insurance, Packaging for transport, Shipment, Clearing from Port including payment of all duties & taxes, In-land transportation from Port to site, Receiving at Site & unloading,, construction, installation, integration, testing, commissioning, Training and performance demonstration of the Solar PV Power Plant and BESS, together with all associated electrical, civil, structural, mechanical, communication, control, protection and auxiliary systems required for safe, reliable and efficient operation of the Project with the GRID Central Control, Monitoring & communication system shall also is in the scope of bidder that will communicate & control the DG power house & Bagasse Power plant along with solar + BESS for stable co-operation into labasa GRID. Installation of required controller & communication system at DG, Bagasse & solar+ BESS power plant is also in the scope of Bidder.

Control Center will communicate with National control centre through dedicated Leased Line over IP protocol. Bidder shall ensure that the required data shall be communicated to NCC and all material & services required for the purposes shall be in the scope of Bidder. Bidder are requested to envisage all the requirement for the same in their scope.

The scope of the EPC Package shall include, but shall not be limited to, the PV modules, module mounting structures, solar inverters, inverter transformers, medium-voltage collection system, Battery Energy Storage System, Battery Management System, Power Conversion System, Energy Management System, plant controller, switchgear, protection and metering systems, Supervisory Control and Data Acquisition system, communication systems, weather-monitoring system (WMS) including cloud monitoring system, auxiliary power systems, earthing and

lightning-protection systems, fire detection and suppression systems, internal roads, drainage, fencing, security systems and all associated civil and structural works.

The EPC Contractor's scope shall extend up to the designated **Point of Interconnection with EFL's electricity network** and shall include all facilities necessary for the monitoring, control, protection, metering and communication interface between the Project and EFL's substation system & Powerhouse. The final interconnection arrangement, plant operating philosophy along with existing DG gen set shall be proposed by the bidder during detailed engineering and shall be in line with the relevant international standards & industry practice and same shall be proposed by the EFL or its representative. EMS, control system, and communication system upgrades of the DG powerhouse and Bagasse power plant, including a redundant communication network, are also within the Bidder's scope to ensure stable and reliable operation with Solar+PV project and central control.

Accordingly, this Technical Specification covers the EPC development of the **12 MWAC Seaqaqa Solar PV Power Plant with a 6 MW/12 MWh Battery Energy Storage System along with Central control system**. The Project shall be designed and constructed to achieve high availability, reliability, safety and operational efficiency throughout a minimum design operating life of **twenty-five years**.

The complete Project shall comply with the applicable laws and regulations of Fiji, EFL's technical requirements and grid-connection requirements, relevant environmental and statutory approvals, and the latest applicable editions of internationally recognised standards, including IEC, IEEE, ISO, NFPA, AS/NZS and other standards identified in the Technical Specification.

1.2 PROJECT CAPACITY

Name of the Project	**EPC Package for 12 MWac Solar PV with a 6MW/12MWh BESS Project at Seaqaqa, Vanua Levu, Fiji**
Plant Capacity	**12 MWAC at Grid Connection Points.** **Bidders shall bid for the entire 12MWAC Solar Capacity along with BESS.**

Termination Point	**LILO connection in the 33 kV line Passing nearby to the Project Location**
Metering Point ``	**Measured at 33kV LILO O/ G Feeder**
POI	**33kV LILO Interconnection Point**

1.3 LOCATION AND APPROACH

Location of Site	**SEAQAQA, VANUA LEVU, FIJI**
Major Road	**Cross island Road,**
Nearest Commercial Airport	**Labasa Airport**
Indicative Coordinate	**16*30'10.74"S, 179* 9'28.99"E**

Project site is adjacent to the seacoast (within 7 KM distance from sea cost).

1.4 AREA AVAILABILITY

Land availability	**Approximately 49.8 Acres.**

Land will be provided by EFL, however clearance of bushes/ vegetation/ trees, levelling grading, cutting & filling including required surface compaction is in the scope of the EPC agency.

1.5 TECHNOLOGY

In Solar Photo Voltaic Power Generation, the direct conversion of solar radiation into electricity is achieved by using semiconductor devices “Solar Cells”, which work on the principles of photo electric effect.

1.6 SITE SPECIFIC TECHNICAL DATA

Refer APPENDIX – 1

1.7 STATUTORY COMPLIANCE, GRID CONNECTIVITY AND POWER EVACUATION

A. The scope of the bidder for power evacuation system shall extend up to the 33 kV LILO interconnect, as shown in the tender SLD. The EPC Contractor shall be responsible for design, supply, installation, testing, and commissioning of the complete 33 kV LILO interconnection including protection, metering, and interface equipment up to the designated terminal point.

Bidder shall comply with all provisions and amendments thereafter of

i. Electricity Act No. 17 of the Republic of Fiji, together with all amendments, regulations including Electricity Regulations 2019 as applicable. and amendments thereof.

ii. Energy Fiji Limited guidelines for renewable energy project development.

iii. Energy Fiji Limited Grid Code.

iv. Applicable international standards, including:

a. IEC 61727: Photovoltaic (PV) systems – characteristics of the utility interface.

b. IEC 62116: Anti-islanding protection for grid-connected inverters.

c. IEEE 519: Harmonic control in electrical systems.

v. Environmental Management Act 2005 & Amendments Thereof

vi. Cybersecurity and SCADA data integration standards as per EFL. SCADA integration with GRID with ISO/IEC 27001 practices for cybersecurity.

vii. All applicable labour, employment, occupational health and safety, and workers' compensation laws and regulations of Fiji, including all statutory requirements relating to wages, working hours, leave entitlements and employee benefits.

viii. Any other national or local regulations, standards, advisories, or project-specific directives issued during the project lifecycle.

B. Solar Inverters & BESS PCS shall be provided with Dual or Multi Master facility, whereas Weather Monitoring System (WMS) shall be provided with Single or Dual Master facility. Bidder shall install and place its SCADA system along with its terminals at CMCS Room. SCADA Network/Communication infrastructure to be integrated with redundant Energy Management System/Power Plant Controller (PPC), as per EFL's communication protocol.

C. Bidder shall conduct detailed Grid compliance (impact) study with Energy Management System/ Power Plant Controller for solar + project as per EFL/its representative requirement and latest guideline for first charging clearance. Bidder shall arrange the GRID related data required for study. In this regard, bidder shall provide all technical details including Inverter and PCS bench marking report, Generic model data of Inverters and PCS, suitable for use in PSS/E and PSCAD software available at EFL and Encrypted user-defined model (UDM)/generic model of Inverter and PCS in PSS/E software (*.dll files) as applicable. Provision of PSCAD model of inverter and PCS shall also be in bidder's scope. Following studies to be included in the report:

a. Steady State and Dynamic Simulation in PSS/E version 34.4 or above and PSCAD version 4.6 or any other software as requested by EFL

b. Reactive Power Performance

c. Flicker, Harmonic and DC Injection Assessment

d. Grid Code Compliance Validation

The "first time charging" (FTC) of a power generating system, also called first-time energization, is the initial process of safely connecting a power source (like a solar PV Plant) to the regional grid. This process involves strict technical, regulatory, and procedural steps to ensure the generating system can operate correctly without causing grid instability, and that it meets all compliance and safety requirements before becoming fully operational.

D. Bidder shall provide simulation-ready control block diagrams, parameter definitions, control settings and model assumptions for all grid-relevant control functions, such as PCS, EMS, PPC and BESS control functions, sufficient to enable recreation and validation of equivalent models in alternative simulation platforms.

E. Bidder shall provide all data used for performing applicable study/simulation reports as per 'Procedure for Integration of solar plant" for submission to EFL for first time charging clearances (as required by regulatory/statutory body).

F. Power variation due to resource side limitation (Cloud Movement) is limited to 3 % of rated power of plant per minute. Battery Energy Storage System (BESS) of minimum 6 MW / 12 MWh capacity at 33kV pooling switchgear, shall be provided and fully integrated with the solar plant and SCADA system to ensure ramp rate compliance of ≤ 3% per minute, BESS shall also be used for Peak demand, GRID stability. Operating Philosophy for the same will be approved during detail engineering, however all the material & services for the same is considered in the scope of Bidder.

G. Bidder shall update themselves latest requirement for technical data requirement/PSSE/PSCAD Model as per EFL requirement. Bidder shall perform the GRID study of Complete Labasa Grid including existing DG power house , Bagasse power plant and proposed Solar+BESS project and submit report within 3 months from LoA. However, the final requirement or any other requirement shall be intimated during detail engineering. Harmonic filter installation for solar+BESS is considered at 33 kV POI of the project.

Grid study shall be done by agency who has already done GRID compliance study for solar +BESS system interacting with GRID. Agency who has done GRID study for ISLANDED GRID operating on solar and DG set shall be preferred.

Following shall be part of submission-

Comparison of field test measurement with simulation results numerical values and as well as graphical values for following points.

a. Power Quality (only in EMT).

b. Active power set change (RMS & EMT)

c. Reactive power control- V control, pf & Q control (RMS & EMT)

d. IBR capability demonstration (RMS & EMT)

e. LVRT (RMS & EMT)

f. HVRT (RMS & EMT)

g. Frequency response (RMS & EMT)

h. Low Frequency Ride Through (LFRT) (RMS & EMT)

I. High Frequency Ride Through (HFRT) (RMS & EMT)

The conclusion section include a summary table identifying the benchmarked models and demonstrating whether the models adequately replicate the measured performance. The deviation between simulated and measured results for all benchmarked parameters shall be minimized and shall not exceed 5%. Bidder shall perform the model validation and submit the validation report within three (3) months following completion of the Commissioning Test. Any required tuning of the PSSE and PSCAD models identified during model validation shall be completed by Bidder at no additional cost.

H. Inclusion of EMT model in PSCAD™ and RMS model in PSSE™ of plant, benchmarking report of model along with dynamic model.

I. Harmonic study, DC Current, Flicker study to be done by Bidder and has to Install Harmonic Filter (if required) to improve the quality of Power as per IEC/IEEE standards.

J. Bidder shall perform power quality and protection audit each year under O&M period and submit the report to EFL/Owners Representative for its approval.

Any corrective/remedial action as required based on the audit recommendations during the O&M period shall be in the scope of the bidder.

K. The Wind Tunnel Study shall be performed by an independent boundary-layer wind tunnel laboratory accredited to **ISO/IEC 17025**, where applicable, or operated by a recognized university or national research institution, with documented experience in testing solar PV arrays and structures located in hurricane or Category-5 cyclone regions. The study shall model the actual site, surrounding terrain, coastal exposure, PV configuration and all critical operating or stow positions, using an approximate design wind speed of **85 m/s** and the governing local standard together with **ASCE/SEI 49 or an approved equivalent**. The agency shall issue a certified report defining local and area-averaged pressure coefficients, uplift, drag, overturning and torsional loads, structural reactions, critical wind directions and design recommendations for the complete load path, including modules, clamps, rails, supports, anchors and foundations; the report shall be independently reviewed by a qualified wind or structural engineer and approved by the Owner/Engineer prior to manufacture and installation.

L. All Major equipment's such as PV Module, Inverter & PCS, BESS, Transformers, HT & LT Switchgear, Cables, UPS, Harmonic Filter, SCADA & EMS etc should be type tested and compliant with IEC/ISO/IEEE (as applicable) Standards and approval of sub-Vendor is required from EFL before procurement and deployment.

M. EPC contractor to comply with the technical minimum specification of major equipment as mentioned in the Technical Specifications. However Bidder may propose a better equipment or specification and approval for the same shall be taken from EFL/owner's engineer during detailed engineering.

All equipment, materials and services, whether explicitly stated in the Technical Specifications or otherwise, that are necessary for the successful commissioning of the Solar+BESS Plant and stable operation into the GRID along with DG & Bagasse power plant in accordance with applicable statutory regulations/procedures issued by regulatory bodies of FIJI, shall be deemed to be included in the scope of work of the EPC Contractor.

1.8 OTHER DETAILS

The following clearances shall be arranged by the bidder. However, necessary documentation/applications shall be in the name of EFL.

SL	ITEM	DETAILS
1	Water Requirement during construction	To be arranged by bidder
2	Power Requirement during construction	To be arranged by bidder
3	ROW clearance	In general, no ROW clearance requirement is anticipated. In case of any minor ROW clearance requirement, Owner shall take up the same and necessary facilitation as required shall be provided by the bidder.

Bidder shall apply for necessary approvals, permits and clearances not more than 90 days from the issuance of LOA, which shall be complete in all respects, incorporating the clarifications/changes as required by the concerned authorities.

All necessary approvals, permits, and clearances (including all the statutory fees for approvals) necessary towards successful completion of project shall be in the scope of bidder (unless otherwise specifically mentioned in document).

1.9 GENERATION LINKED BANK GUARANTEE & COMPREHENSIVE AMC

Refer **APPENDIX – 2**.

1.10 FACILITIES FROM EFL FOR THE PROJECT

Refer **APPENDIX – 3**.

1.11 DISPOSAL OF HAZARD/ WASTE

EPC bidder shall be responsible for safe removal and disposal of toxic, hazardous and dangerous waste generated at site during project and O&M phase as per the guidelines issued by local statutory body.

1.12 UNDERGROUND UTILITIES DETECTION AND PROTECTION

The Contractor shall be fully responsible for the verification, identification, and detection of all existing underground utilities (including but not limited to electrical cables, communication lines, water pipelines, sewerage/drainage networks, gas pipelines, and any other buried services) within and adjacent to the project site prior to commencement of any construction/ excavation works. All needful permissions may be taken from concerned authorities.

Contractor shall take all preventative measures to avoid damage to existing utilities. Any damage arising due to failure in detection, improper protection, or negligence shall be rectified at the Contractor's cost without impact on the project schedule.

APPENDIX – 1 SITE SPECIFIC TECHNICAL DATA

A. SOLAR INSOLATION DATA FOR PROPOSED SITE (FOR THE PURPOSE OF ENERGY ESTIMATION)

Month	Solar Insolation (kWhr/m^2)
January	176.0
February	110.8
March	146.9
April	110.2
May	113.5
June	101.5
July	112.1
August	152.7
September	144.9
October	130.4
November	183.8
December	168.6
Year	**1651.3**

#Source: SOLARGIS

System Unavailability of minimum 2% in terms of energy shall be considered by bidder in PVSyst for estimation of annual generation. This includes the loss due to data inaccuracy /data variability also.

Additionally, Soiling loss of minimum 1.5% in terms of energy shall be considered by bidder in PVSyst for estimation of annual generation.

B. MODULE MOUNTING – FIXED-TILT TYPE MMS

The minimum design clearance (at the highest tilt angle) between the lower edge of the modules and the developed ground level shall be **500mm for Fixed Tilt MMS system**.

C. CABLE LAYING METHODOLOGY

Bidder can propose suitable cable laying methodology, keeping in view of the site conditions, which shall be reviewed during the detail design engineering.

D. PROJECT LOCATION CLASSIFICATION (CORROSION PROTECTION)

Parameter	**Coastal/Non-Coastal**	**Corrosive Category (as per ISO12944-2)**
Corrosive category	**Coastal**	**C5 (High)**

NOTE w.r.t Corrosion Protection

i. Concrete capping of minimum 500 mm above finished ground level shall be provided for all MMS foundations, designed considering C5- (high) exposure.

ii. Concrete capping for MMS Piers will have sloping finish to avoid water stagnation, without any change in net volume of concrete.

iii. For sub-structures, the chemical aggressiveness of sub soil & ground water shall be as per approved geotechnical investigation report. The design and material selection shall comply with BS EN 206, Eurocode 2 (EN 1992-1-1), or equivalent international standards (ACI 318 / ASTM C150 / BS 8500), based on which appropriate corrosion protection measures (e.g., sulphate-resistant cement, corrosion resistant/epoxy-coated reinforcement, increased cover depth, or cathodic protection) shall be adopted.

Pollution from industries/ factories/ mines etc. shall also be considered while deciding the corrosion category depending on the level of pollution to which location is exposed.

Corrosive category (for Paints)

Classification of environments for Corrosive category shall be in accordance with ISO12944-2 (latest revision), the applicable atmospheric corrosivity categories are C3 (medium); C4 (high); C5-I (very high-industrial); C5-M (very high-marine).

ISO12944-5 (latest revision) shall be used related to paint systems in combination with guidance for the selection of different types of protective paint systems.

LT electrical panels, UPS, SCADA panel, Fire protection panel etc. associated with Inverter station are to be placed indoor, the enclosure of the same should be IP55 minimum (IEC 60529), powder-coated or painted as per ISO 12944-5 for C5 category having proper ventilation system. The temperature rise should not be more than the working temperature of components.

All corrosion protection systems should be designed and manufactured for a minimum 25-year service life.

E. RAINFALL:

For official rainfall data for Labasa, Fiji, as per Fiji Meteorological Service (FMS), which publishes rainfall observations and climate summaries.

One recent FMS climate summary reported:

Labasa Airfield monthly rainfall: 319.7 mm (May 2025).

Average annual rainfall in Labasa: approximately 2,000–2,500 mm per year.

Wettest months: January–March.

Driest month: July

F. SEISMIC DATA & DESIGN CRITERIA

The seismic design of all civil and structural works shall comply with the site-specific seismic parameters, and with internationally recognized standards such as BS EN 1998, ASCE 7, ACI 318, or equivalent, consistent with the Applicable Codes and Standards listed in the technical specifications.

G. WIND DATA & DESIGN CRITERIA

Basic wind speed for design shall be taken as 85 m/s (3-second gust at 10 m height above ground level).

All structures shall be designed for wind loads in accordance with AS/NZS 1170.2 for wind region D, as applicable, and consistent with the Applicable Codes and Standards listed in sub-section 2-C of Part-A of the technical specifications. The terrain shall be considered as category 2 (TC2).

Bidder shall calculate the design wind pressure (pa) as per provisions of the above codes.

All structures shall be designed for a minimum 25-year service life, ensuring structural safety, serviceability, and durability under the governing wind load conditions.

H. MODULE CLEANING SYSTEM

Bidder shall propose solar modules cleaning system with water through pipe network, pumping stations, storage etc. For water-based module cleaning system, bidder must ensure the availability of suitable water for module cleaning, installing water softeners or industrial RO as needed, and provide a long-term water arrangement, including all necessary approvals.

I. Road Terminology:

- Main approach road(s) is/are the existing Govt. Roads (National Highways, Secondary Roads or Local Roads).
- Approach Road is the road from the Main approach road to the plant boundary/Main gate.
- Internal road(s) are the road(s) developed inside the plot by the Bidder as per the Bidder's proposal.

J. Annexures to Technical Specifications: Following Annexures may be referred:

i. Annexure-1: Environment Impact assessment report for the proposed 12 MW Solar Power Project at Seaqaqa

ii. Annexure-2: Geotechnical study conducted for the proposed 12 MW Solar Power Project at Seaqaqa

iii. Annexure-3: Detailed Feasibility Study Report

iv. Annexure-4: Topography Survey Report

APPENDIX – 2 GENERATION LINKED BANK GUARANTEE & COMPREHENSIVE AMC

A. PV Module Performance Insurance:

To ensure faithful performance of PV modules, Bidder must submit PV Module Insurance with a coverage of a minimum of 6 % of total order value of the module supplies envisaged under the contract for 25 years, with the employer as its beneficiary. Any financial implication encountered due to insurance shall be borne by the bidder.

The following clauses are to be complied:

1) The insurance has to be issued from one of the companies listed below:

a. Swiss RE
b. Munich RE
c. Power Guard
d. Ariel RE
e. If above companies are not available then any other company after approval of EFL may be selected.

2) In case of insolvency of the contractor, the Employer under the terms of the insurance policy against Module Performance and Warranty shall be entitled to raise a claim against the Module Warranty Insurance Policy and to benefit from the coverage provided by the aforementioned policy. The Contractor shall be responsible for maintaining the coverage always provided under the Module Warranty Insurance Policy, at its cost and expense.

3) Further, the Contractor to note that Employer requires the following to be complied while covering the Warranty/Guarantee/Performance of the supplied goods under the insurance:

a) Single Insurance Policy for Product Warranty/Guarantee and performance before dispatch of the first lot of PV Modules Insurance.

b) The Insurance Policy shall be valid for a minimum period of twenty five (25) years from the date of receipt of the last batch/lot of equipment at site.

c) The premium charges, recurring charges, any other expenditure under the Insurance Policy shall be covered by the Contractor.

d) The insurer must continue to compensate end users for warranty claims for the product quality and/or performance even if the contractor ceases to exist as an independent operating company.

e) The insurance shall be non-cancellable by the insurer and shall provide third party bankruptcy rights.

f) Coverage under the insurance policy shall be immediate, without any waiting period.

B. Bank Guarantee for O&M period and AMC of the equipment

The Bank Guarantee shall cover but not limited to:

(i) Overall system performance and generation guarantee during the O&M period

(i) AMC of the equipment and

(iii) Other obligations specified elsewhere in the contract during O&M and AMC period.

The requirement of Comprehensive AMC of Critical Equipment is revised as follows:

Equipment/System	Comprehensive AMC*
Inverter	10 Years

SCADA with PPC	10 Years
BESS with BMS and EMS	10 Years
CCTV System	10 Years
WMS including Cloud Monitoring and forecasting system	10 Years
Harmonic Filter Equipment (if required)	10 years

** Starts from date of commissioning of full capacity*

The contractor shall carry out regular predictive maintenance during the entire AMC period through OEM or OEM authorized service provider.

APPENDIX – 3 FACILITIES AVAILABLE AT THE SITE

1. The approach road (National Highway, Secondary Roads and Local roads) as per the vicinity map.
2. Approx. 50 Acre land shall be provided.
3. Permission for Tree cutting in the project area shall be provided.

Refer Tender Drawings, Annexures and Notes mentioned for more clarity w.r.t Site Specific Considerations.

Note - All temporary arrangements w.r.t approach roads, drainage, office set up etc., as necessary to take up the project construction work, would be in bidder's scope.

2. INTENT OF SPECIFICATION

2.1 INTENT OF SPECIFICATION

The scope of the proposal shall be Site Survey & studies, Grid Studies, Design, Engineering, testing, inspection, insurance, Packaging, shipment, clearing from port, delivery at site, Construction, Erection, Testing, training and Commissioning of Solar PV Plant with BESS (the Plant) at Seaqaqa, Labasa, Fiji along with LILO connection with existing 33 kV network. Centralized control system for remote monitoring & control of DG & Bagasse power plant along with operation of Solar+BESS plant as per GRID requirement is also in the bidders scope. Transmission of data to NCC & backup server of EFL through leased line is also in the scope of bidder. The scope also includes three (03) years Operation and Maintenance (O&M) of the solar PV plant with BESS as well as Annual Maintenance Contract (AMC) of critical equipment for a period of ten (10) years. The scope of work covers the following activities and services in respect of all the equipment and works specified and covered under the specifications and read in conjunction with "Scope of Supply & Services" elaborated elsewhere.

All equipment, materials and services, whether explicitly stated or otherwise, that are necessary for the satisfactory operation of the Solar PV system with BESS and its integration with the existing GRID, communication systems and control systems of the existing DG power plant and Bagasse power plant, shall be deemed to be included in the scope of work of the EPC Contractor. The trouble-free integration and operation of the Plant into the existing DG sets and Bagasse power plant shall be the responsibility of Bidder. Any communication networks and controllers required at the DG power plant and/or Bagasse power plant for load reference and control purposes shall be included in the bidder's scope.

1) Basic Engineering of the plant and systems.

2) Hydrology Study, Grid Impact Study and Protection Study and all other necessary investigations as stated elsewhere in the document

3) Detailed design of all the equipment and equipment system(s) including civil works mentioned elsewhere in this document.

4) Providing, Review and approval of engineering drawings, data, process Calculations, test procedures, Structural Design Calculations, Equipment Layout, Drawings / Data sheets of bought out items, Civil Structural / Architectural Drawings, PG Test etc.

5) Providing Operation & Maintenance/ instruction manuals, as built drawings and other information

6) Providing training of EFL or its authorized personnels.

7) Finalization of sub-vendors, manufacturing quality plans and Field quality plans

8) Complete manufacturing including conducting all type, routine and acceptance tests; Civil, Structural and Architectural works to the extent applicable, including construction facilities and construction power distribution.

9) Packing and transportation from the manufacturer's works to the site, including customs clearance, port clearance, and port charges (if any).

10) Receipt, storage, preservation, conservation and handling of equipment at the site. Fabrication, pre-assembly (if any), erection, testing, pre-commissioning, commissioning, and placing all the equipment into satisfactory operation, including successful completion of the initial operation period.

    Obtaining all permits, permissions, and approvals required for the commissioning activities.

11) Reliability and functional guarantee tests after successful commissioning of the full plant capacity.

12) Supply of spares.

13) Satisfactory completion of the contract.

14) Special tools and tackles if any required for maintenance of the plant.

15) All equipment, materials and services that are necessary for implementation of the reactive power compensations system/harmonic filters etc. as per the grid study with satisfactory operation of the Solar PV system and its integration with the existing AC Systems.

16) Comprehensive Operation and maintenance of the solar plant & BESS.

17) Forecasting and scheduling during the O&M period as per guidelines/procedures of EFL/Other nodal agencies.

18) Safety and security of the project during construction and O&M period.

19) The work covered under the above scope shall be carried out in accordance with the requirements, conditions, appendices, and other provisions specified in these Technical Specifications, together with those stated in other Sections and Sub-sections of the Bid Documents. Such provisions shall be deemed to form an integral part of these Technical Specifications.

    It is not the intent to these Technical Specifications to describe every aspect of the design and construction. Nevertheless, all equipment and civil works shall conform to good engineering practice and shall be designed and constructed to a high standard of engineering, workmanship, and quality.

    The plant shall be capable of reliable and continuous commercial operation in a manner acceptable to the Employer.

    The Employer shall have the right to interpret the intent of the specification and drawings and to reject or accept any work, material, or equipment that, in the Employer's opinion, does not comply with the requirements of these Technical Specifications and/or the applicable international standards reference herein.

20) Bidders are requested to carefully examine and understand the specifications and seek clarifications, if required, to ensure that they fully understand the requirements. Such clarifications shall be sought within the time period as stipulated in Section Instruction To Bidders. The Bidder's offer shall not include any qualifications, interpretations, assumptions, or clarifications that deviate from the requirements of the Bid Documents. However, if the Bidder considers that certain features of its offer are superior to those specified, such features may be highlighted separately.

21) The Bidder shall be responsible for providing all material, equipment and services specified or otherwise which are required to fulfill the intent of specification and ensure operability, maintainability and the reliability of the complete work covered under this specification.

22) Failure of any equipment to meet the specified requirements of tests carried out at work or at site shall be sufficient cause for the rejection of the equipment. Rejection of any equipment will not be held as a valid reason for delay in completion of the works as per schedule. The contractor shall be responsible for removing all deficiencies and supplying the equipment that meets the requirement.

23) Before submitting its bid, the Bidder shall inspect and examine the site and its surroundings and satisfy itself regarding:

a) the nature of the ground and subsoil;

b) the quantities and nature of the works;

c) the availability of materials required for completion of the works; and

d) access to the site

The Bidder shall obtain all information necessary regarding risks, contingencies, and other circumstances that may influence or affect its bid.

No claim arising from any misunderstanding of, or failure to properly assess, such conditions and circumstances shall be accepted by the Employer.

2.2 SCOPE OF WORK

- Detailed design of Grid Interactive Solar PV Plant with BESS, civil, electrical & mechanical auxiliary systems including preparation of foundation drawings, single line diagrams, installation drawings, electrical layouts, design calculations etc. Design memorandum and other relevant drawings and documents required for engineering of all facilities within the scope to be provided under this contract, are covered under the contractor's scope of work.
- Works related to site clearance including removal of bushes, trees, levelling, grading, finishing and other additional works in the scope of bidders. Mandatory permission/ licenses/ statutory clearances from Competent Authorities for undertaking blasting related works, disposal of cutting material, etc. shall be carried out by the Bidder.
- Detailed system wise scope is elaborated in (Electrical Equipment & Works), (Civil Works) & (Miscellaneous Works).

2.3 TENDER DRAWINGS

The list of drawings listed in the Technical Specification shall form part of the specification and shall supplement the requirements specified in these technical specifications. These drawings are preliminary drawings for bidding purpose only and subject to changes that may be necessary during the detailed engineering keeping the basic parameters as specified. Various parameters for building and other equipment specified in the tender drawing are the minimum required and any increase in these parameters if required to meet the system requirement shall be made by the Bidder without any additional cost implication to Employer.

3. PROVENNESS

3.1 PROVENNESS CRITERIA

The Bidder/Sub-vendor(s) is required to meet the Provenness criteria and/or qualification requirement for critical components and bought out item as per the criteria stipulated below:

3.2 Solar PV Modules

The Bidder/Sub-vendor shall meet the requirement as stipulated in para (a) and (b) below for supply of Solar PV Modules:

a. The Bidder/Sub-vendor shall be a Tier-1 PV Module manufacturer listed in the latest Bloomberg NEF quarterly report available as 20 days before the Deadline for Submission of Bids and shall have a proven track record of manufacturing PV modules for **the last five (5) years as of the Bid Submission Date.**

The Bidder/Sub-vendor shall have a minimum annual PV module production capacity of 1,500 MW.

and

b. The Bidder/Sub-vendor shall have deployed PV modules in operational projects with a cumulative installed capacity of at least 3,000 MW, and such projects shall have been successful operation for **at least six (6) months prior to the Bid Submission Date.**

3.3 BESS:

The Bidder/Sub-vendor should have experience in the design and supply of grid connected Battery Energy Storage Systems (BESS) with a cumulative installed capacity of at least 100 MWh. Among these, at least one project shall include a BESS with a minimum installed capacity of 20 MWh, deployed in a microgrid and integrated with solar generation, wind generation, or both. The proposed BESS shall utilize a grid-forming PCS capable of frequency and voltage regulation.

The Bidder/Sub-vendor shall have successfully implemented at least one operational microgrid project incorporating a BESS, Energy Management System (EMS), and grid-forming PCS. The EMS shall have demonstrated successful operation of the following functions:

(i) Renewable generation dispatch and curtailment management;

(ii) BESS charge/discharge optimization;

(iii) Diesel generator coordination and dispatch;

(iv) Spinning reserve management;

(v) Frequency regulation;

(vi) Voltage regulation; and

(vii) System operation under high renewable energy penetration conditions.

The Sub-vendor shall source battery cells/packs from a Tier-1 energy storage manufacturer listed in the latest BloombergNEF (BNEF) report available as of the Bid Submission Date.

Furthermore, the referenced BESS installations and microgrid projects shall have been in successful operation for at least **six (6) months prior to the Bid Submission Date.**

3.4 Solar Inverter Transformers

The Bidder/Sub-vendor shall meet all of the requirements specified in (a), (b) and (c) below.

a) The Bidder/Sub-vendor shall have designed, manufactured and supplied transformers (aluminum- or copper-wound, as offered) of 33 kV or higher voltage class, with a cumulative supplied capacity of at least 50 MVA. Among these, at least one project shall include a supply of transformers with a total capacity of not less than 10 MVA.

The reference project in which transformer(s) with a total capacity of 10 MVA or greater were supplied shall have been in successful operation for **at least six (6) months prior to the Bid Submission Date**.

b) The Bidder/Sub-vendor shall have its own facilities capable of conducting all routine transformer tests in accordance with IEC 60076 and applicable AS/NZS standards.

c) At least one inverter transformer rated 2.5 MVA and 33kV voltage class or above, manufactured by the Bidder/Sub-vendor, shall have successfully passed a short circuit test within 10 years prior the Deadline for Submission of Bids.

3.5 Solar Inverter

The Bidder/Sub-vendor shall meet all of the requirements specified in (a), (b), and (c) below:

(a) The Bidder/Sub-vendor shall have designed, manufactured, and supplied grid-connected solar inverters with a cumulative installed capacity of at least 100 MW. Among these, at least one project shall have an installed inverter capacity of not less than 50 MW.

In addition, the Bidder/Sub-vendor shall have experience in the design, manufacture, and supply of grid-connected solar inverters installed in a microgrid or island-grid environment. The reference project shall be in a system where the majority of the load is supplied by DG and the maximum system demand does not exceed 100 MW.

The above reference projects shall have been in successful operation for **at least six (6) months prior to the Bid Submission Date**.

(b) The Bidder/sub-vendor shall have in-house facilities capable of conducting routine inverter tests in accordance with applicable IEC and AS/NZS standards.

(c) The offered solar Inverter model, or an inverter model from the same product family, or a similar inverter-topology model utilizing the same make of solid-state power switching device, shall have been in successful operation for at least three (3) years prior to the Bid Submission Date. The inverter product family model or similar inverter-topology model shall have a power rating not less than 50% of the rating of the offered inverter model. The similar inverter-topology model shall have an identical power

circuit configuration and the same maximum DC input voltage rating as the offered inverter model. The Inverter product family model or similar Inverter-topology model shall be subject to technical assessment to establish its similarity to the offered inverter model and shall be subject to EFL's review and acceptance.

Note:

(i) Only inverter ratings of 1.0 MW or above for central inverters and 350 kW or above for string inverters shall be considered for capacity determination.

(ii) It is recommended to provide solar inverter & BESS PCS from same manufacturer for better coordination & conveninence during O&M period.

3.6 HT Power cables (3.3kV and above but below 33kV)

The Bidder/Sub-vendor shall have manufactured, type tested to Australian Standards and supplied the following cables prior to the Bid Submission Date.

(a) At least 100 km of XLPE insulated power cables with a voltage rating of 1.9/3.3 kV or higher, supplied under one or more contracts, limited to a maximum of three (3) contracts.
(b) At least one (1) km of flame-retardant low-smoke cables of any voltage rating.
(c) The project(s) for which the above cables were supplied shall have been in successful operation for **at least six (6) months prior to the Bid Submission Date**.

3.7 HT Power cables (33kV)

The Bidder/Sub-vendor shall have manufactured, type tested to Australian Standards and supplied the following cables **prior to the Bid Submission Date**.

(a) At least 20 km of XLPE insulated power cables with a voltage rating of 19/33 kV or higher, supplied under one or more contracts, limited to a maximum of three (3) contracts.
(b) At least one (1) km of flame-retardant low-smoke cables of any voltage rating.
(c) The project(s) for which the above cables were supplied shall have been in successful operation for **at least six (6) months prior to the Bid Submission Date**.

3.8 DC Solar cables

The Bidder/Sub-vendor shall have manufactured, type tested to Australian Standards and supplied the following cables **prior to the Bid Submission Date**.

(a) At least 150 km of XLPO insulated DC Solar cables with a voltage rating of 0.63/1.1 kV or higher and minimum 4 sq mm size, supplied under one or more contracts, limited to a maximum of three (3) contracts.

(b) The project(s) for which the above cables were supplied shall have been in successful operation for **at least three (3) years prior to the Bid Submission Date**.

Note: If the DC solar cable manufacturer does not independently satisfy the requirements specified in Clause (a) and/or (b), the credentials of its parent company, holding company, subsidiary company, associate company, or technology partner engaged in the manufacture of DC solar cables may be considered, provided that an acceptable technology tie-up arrangement is in place.

Form-A

Undertaking from Main Contractor

(On letter head signed by a duly authorized person along with company/firm's seal on behalf of the Main Contractor)

Date:

To

EFL,

Engineering Deptt/ EIC (as applicable)

Subject: Authentication of veracity of documents submitted by M/s .....in support of meeting the provenness requirements mentioned in technical specifications.

Name of Item/work for which provenness documents are submitted: .....

Dear Sir,

We ..... (Main contractor name) hereby propose M/s. ..... having Registered office at..... as sub vendor for the aforementioned item/ work in referred tender of EFL.

The tender condition stipulates that the main contractor shall duly verify, certify for its authenticity & correctness, and submit the credential documents of sub vendor pertaining to provenness criteria.

In this regard, it is hereby confirmed that we have examined the following documents, which are also attached with this letter. The same has been verified from the Original Documents and/ or Client for authenticity and correctness.

We hereby confirm that the following documents are found to be genuine and authentic.

1. ..... Doc ref. no. ..... dated (name of Documents)

2. ..... Doc ref. no. ..... dated (name of Documents)

3. ....

All the aforesaid documents have been signed by us as a certificate of authenticity.

Thanking you.

4. ELECTRICAL SCOPE OF SUPPLY & SERVICES

4.1 BASIC ENGINEERING DESIGN PARAMETER OF SOLAR & BESS PLANT

a) Plant Capacity at POI: 12MW$_{AC}$: The Bidder shall limit the active power output of the Renewable Energy Plant at the POI (as defined in the project information) to the Project Capacity (MWac), so that the power injected into the grid does not exceed the Project Capacity. The Bidder shall demonstrate through the PVSyst study and the proposed EMS control philosophy that the active power injected at the POI will not exceed the Project Capacity of 12 MWac under all operating condition. Reactive power capability at the POI shall comply with latest EFL Regulations.

b) Inverter Capacity/rating: The continuous combined rating of all PCUs/ inverters shall be sufficient to inject rated MWac at the POI, together with the required reactive power, at ambient temperature of 45 deg Celsius and in accordance with the applicable Grid Code.

c) BESS: The BESS should be designed to provide voltage and frequency regulation to the grid while also meeting the evening peak demand requirements. Please refer technical specifications for other detailed specifications.

d) The reticulation system (kVA rating of cable, transformer etc.) shall be designed to withstand maximum generated Inverter apparent power at that ambient condition.

e) The use of a common inverter size throughout the plant is recommended. The use of a common inverter transformer rating is also preferred to facilitate mandatory spare parts management. BESS PCS & Solar inverter shall be preferred from same OEM for better integration & after sales service.

f) Harmonic Filter requirement for 12 MWac Block (if required):

The allowable waveform distortion at the POI shall be limited to the indicative planning levels specified in Table 2 of Clause 4.1.1 of IEC 61000 -3-6 (Harmonics).

The Bidder shall ensure that the Total Harmonic Distortion (THD) contributed by the Plant at the POI does not exceed 50% of the limits specified in the table below:

Odd Harmonics Non- Multiple of 3						Odd Harmonics Multiple of 3		Even Harmonics	
Harmonic Order H	Harmonic Voltage %	Harmonic Order H	Harmonic Voltage %			Harmonic Order H		Harmonic Voltage %	
			5			2		2	
			1.5			4		1	
			0.4			6		0.5	
			0.3			8		0.5	
17<h<49				227* 17/h-0.27		21<h <45		10<h <50	0.25* 10/4 +0.25
Note: The compatibility level for THD shall be 8%.									

Harmonic analysis and compliance assessments shall be conducted in accordance with IEC 61000.3.6:20212 and shall also comply with the requirements of the latest EFL Grid Code, including compliance with IEEE 519 or an equivalent standard.

The Bidder shall perform a harmonic analysis for the proposed the Plant and submit the harmonic analysis report to EFL during the design stage.

The successful Bidder shall conduct background harmonic measurements at the POI for a minimum period of two (2) weeks during the design stage in accordance with IEC 61000-3-6: 2012. Based on the measured background harmonic levels and the harmonic analysis, the Bidder shall determine and provide any harmonic mitigation measures, including harmonic filters if required, to ensure compliance with the specified harmonic limits. If the Bidder fails to conduct adequate background harmonic measurements, then the post commissioning harmonic measurements shall be below the harmonic levels in the above table.

Following commissioning and connection of the Plant to the grid, harmonic measurements shall be performed at the POI to demonstrate compliance with the limits specified above. The measurements and analysis shall be conducted in accordance with IEC 61000.3.6:2012.

g) **33 kV Local Pooling Switchgear**

1) Bus Bar rating of the HT Switchgear: As per Tender SLD.

2) System Fault Current Rating: As per Tender SLD.

3) Dynamic withstand Current rating: 2.5 times the system fault current.

4) DC Supply shall be used for the control and protection system of the switchgear. If a UPS AC supply is used for auxiliary control and protection power supply for the switchgear (except CMCS), a suitably rated AC/DC converter or power pack shall be provided to meet the DC control power supply requirements of the switchgear panels.

5) The 33kV switchgears (both indoor and outdoor type wherever allowed in accordance with Technical Specification) shall have an internal arc classification suitable for the applicable system fault current level.

6) The switchgear shall be cooled by natural air flow. Forced cooling shall be provided where the current rating is 2000 A or above.

h) **Construction of One (1) Storeroom**

Construction of one (1) storeroom with a minimum built-up area of 100 m^2 and a minimum width of 7 m.

i) Outdoor containerized solution or compact substations incorporating the inverter, inverter transformer and HT switchgear are acceptable as inverter station. However, the technical specifications for the inverter, HT switchgear and inverter transformer specified in the relevant Clause of this Technical Specification shall apply.

j) **Earth Pit for DC System**: One (1) earth pit per 1.0 MWp.

The above requirements is applicable provided that all the earth pits are interconnected to form a single earthing mesh.

k) **Metering:** As per SLD in the Technical Specification. For grid interconnection and metering, the EPC contractor shall comply with the relevant EFL Regulations, the Grid Code, and any other applicable regulations in Fiji, as amended from time to time. Metering and associated equipment for the Plant in accordance with SLD, shall be supplied and installed by the Bidder. Meters shall comply with the applicable codes and standards.

It is necessary to install power quality meters at two 33 kV feeders (and in a spare panel) to monitor post-commissioning power quality. The meters shall be capable of sampling at 1024 samples per cycle and retaining the recorded data for a minimum period of one (1) year.

l) **Module Cleaning System:** Water based wet module cleaning system is envisaged.

m) **Cable sizing criteria:**

Only single-core 19/33kV HT cables shall be offered for the project, with the armour serving as the metallic screen. The conductor and armour shall each be capable or withstanding the system fault current.

The minimum cable size (for both conductor and armour individually) for 33kV applications shall be determined based on protection time grading requirements, subject to a minimum duration of 0.5 s. For any cable feeder, the minimum duration for cable sizing calculations (for both conductor and armour individually) shall be the relay operating time setting of the immediate upstream breaker (towards the grid) plus 100 ms, or 0.5 s, whichever is greater. For the final power evacuation circuit from the HT switchgear to the POI, the minimum duration used for cable sizing calculations shall be 1.0 s.

n) **SCADA:** Four (4) remote monitoring licenses hall be provided for the SCADA system, with provision for simultaneous access by all authorized users. Please refer to the detailed technical specifications provided elsewhere in this document for the SCADA system and the Power Plant Controller (PPC).

o) **Weather & Cloud Monitoring system with Forecasting Feature:** Provision of a weather and cloud monitoring system with an advanced forecasting feature to detect cloud movement and predict changes in GHI at the project site for the next 30 minutes, with GHI data available at one-minute intervals. The cloud monitoring system shall provide cloud movement detection and GHI forecasting capability and shall include integrated irradiation, humidity and temperature sensors, together with a data acquisition and data transmission system to improve data accuracy. Please refer to the detailed specification provided elsewhere in this document for the weather monitoring system.

p) **DC and LT Power cable voltage drop criteria**: The maximum voltage drop from the PV modules to each inverter transformer shall be limited to 3% of the rated voltage. For all other LT cables, the maximum voltage drop shall be limited to 3% of rated voltage. A 1.9/3.3 kV grade LT cable shall be used for the connection between the inverter and the inverter transformer.

q) **DC system voltage**: DC system voltage of 125 V/250 V respectively shall be considered for equipment rating and design, which has auxiliary voltage fed from 110V/220V battery.

r) **Closed Circuit Television (CCTV) and Monitoring System**: The CCTV system shall provide 100% coverage of the perimeter and entry/exit gates of the solar block(s). In addition, the CCTV system shall provide 100% coverage of all inverter stations, the storeroom, the security room, and all Weather Monitoring System (WMS) locations. For detailed CCTV system requirements, refer to the relevant clause in this document.

s) **Forecasting and Scheduling**: The Bidder shall comply with the forecasting and scheduling requirements issued by EFL and/or other relevant authorities during the contract period.

The detailed scope of work in accordance with this specification is elaborated below. The scope of the contractor shall be deemed to include all such items which although are not specifically mentioned in the bid documents and/or in contractor's proposal but are needed to make the system complete in all respects for its safe, reliable, efficient and trouble-free operation. Such items shall be supplied and installed unless specifically excluded under the section Terminal Points & Exclusions.

4.2 SUPPLIES & ASSOCIATED WORKS

DC SIDE	
•	Solar PV Modules
•	Fixed Tilt Module Mounting Structure along with foundation
•	DC Cables including field connectors and DWC pipes
•	String Combiner Box (if applicable)
•	Power Conditioning unit
AC SIDE	
•	LT Switchgear
•	HT Switchgear
•	Inverter & PCS Transformer& Auxiliary Transformer
•	LT Cables
•	BESS with PCS, BMS & EMS
•	HT Cables
•	Cable Laying – DC, LT & HT cables
•	SCADA & Time Synchronization Equipment
•	Instrumentation and Communication cable
•	Earthing System
•	Lightning Protection System
•	Plant Illumination system

•	Auxiliary Power Supply System
•	Battery and Battery Charger
•	UPS
•	Power Quality mitigation devices (if required)
•	Grid interfacing to meet statutory requirements and comply with EFL Grid code.
GENERAL SYSTEMS	
•	Weather Monitoring Station and forecasting system with advanced cloud monitoring system
•	Fire Detection and protection system
•	Water based Module Cleaning system including source of suitable water.
•	Closed Circuit Television (CCTV) and Monitoring System

4.3 POWER EVACUATION SYSTEM, TELEMETRY & SCADA.

Power Evacuation System: EFL 33 kV transmission line is passing near to Project location (opposite of Island Road). LILO interconnection is envisaged for connection with the proposed plant and shall be as per tender SLD. All work of LILO connection from 33 kV pole to interconnecting switchgear and finally connecting the outgoing line is considered in the scope of the Bidder. Road passing, H-Pole or Four Pole structure, 33 kV HT cable, Isolator, surge arrestor, insulator and required modification in existing transmission line & poles is considered in the scope of the Bidder.

4.4 SCADA, Telemetry and Telecommunication for Solar PV Plant:

All the signals related to renewable energy facility and its controllers shall be configured in accordance with the IEC 60870 – 5 – 104 protocol. Gateway configuration parameters and communication interfaces shall be configured in accordance with latest applicable AS/NZS standards. The finalized signal list shall be submitted as part of the Detailed Design Submission.

The final configuration of database, project files and gateway image (Acronis true image) and backup files shall be submitted in the form of portable external hard disk.

The telecommunications facility shall be compatible with the international standard system and common industry practices for solar power plants and shall include:

- Fixed-line telecommunications with PABX facilities;

- Wireless communications;
- Fiber optic line from the Plant up to the Point of Interconnection (POI);
- A direct communication link with the EFL National Control Centre.

Currently Digital Radio is being used for communication between DG & Bagasses power plant. Solar+ BESS project need to communicate with the DG & Bagasse power plant for GRID stability & control. Bidder may use the Digital radio communication protocol for the same or may prefer the other wired communication system. However based on the site requirement & proposed shall be capable of providing sufficient reliability and ease of O&M. In digital radio system, repeaters if required shall be installed by the bidder and land & other infra required for this shall be considered in the scope of bidder.

. IP phones shall be made available at the Plant, the existing DG powerhouse & Bagasse power plant to provide voice communication facilities. Specifications of the IP phone and firewall shall be subject to the review and approval of EFL.

The SCADA and all other related systems shall be capable of synchronizing their clock via the Network Time Protocol (NTP) using the time synchronization equipment supplied under this package.

4.5 SYNCHRONIZING:

Project shall be capable of automatic, unattended operation unless manual overriding is enabled for local manual controlling. The Plant shall be automatically synchronized to the Labasa Grid.

4.6 LOAD FOLLOWING CAPABILITY / DISPATCHABILITY:

i) The project shall be capable of providing:

- Voltage control;
- Frequency control;
- Grid-forming operation
- Black-start capability;

- Stable operation under low short-circuit ratio (SCR) conditions (Less than 2);
- Inverter droop control functionality; and
- BESS PCS droop control and/or isochronous operation, as required.

ii) The project shall be capable of reducing active power output with adjustable droop settings in the range of 3% to 10%. Exact droop setting in co-ordination with DG set & Bagasse power plant shall be decided during detailed engineering.

iii) The Plant shall be controllable in terms of active power output in accordance with grid requirements to support system stability and mitigate system imbalance. The facility shall be capable of reducing active power output from any operating condition and from any operating point to a target value, up to the maximum project capacity.

4.7 FAULT RIDE-THROUGH CAPABILITY:

The Project Facility shall be capable of remaining synchronized with the grid during and following any symmetrical or asymmetrical fault/disturbance in the grid.

4.8 CURRENT DISTORTION LIMITS:

Current harmonic distortion shall comply with the limits specified in Clauses 6, 7, 8, and 9 of IEC 61000-3-6 (Harmonics) and the latest edition of IEEE 519.

Measurement, evaluation, and reporting of current harmonic distortion shall be carried out in accordance with IEC 61000-3-6 and the latest edition of IEEE 519.

4.9 VOLTAGE FLUCTUATION EMISSION LIMITS:

Voltage fluctuation emissions from the Facility shall comply with the limits specified in Clause 6, 7, 8 and 9 of IEC 61000-3-7(Voltage fluctuation).

Measurement, evaluation and reporting of voltage fluctuation emissions shall be carried out in accordance with IEC 61000-3-6 and IEC 61000-3-7.

4.10 UNBALANCED LOADING CAPABILITY:

Design of the project Facility shall enable it to remain synchronized in the grid under voltage unbalance as specified in IEC 60034-1 or Clause 6.5 of IEC 61400-1, whichever is the highest.

In addition, under unbalanced fault conditions in the grid, the Plant shall be capable of withstanding the resulting negative sequence loading and also remain connected to the grid, until the fault is cleared.

4.11 RAPID VOLTAGE FLUCTUATION:

The Bidder shall ensure that, irrespective of the operating status of the Plant, the facility does not cause rapid voltage fluctuations exceeding the limits specified in the following table. The guidelines relating to rapid voltage fluctuations are provided in TR IEC 61000-3-7: 2012.

Number of changes (n)	ΔU/UN % MV
$n \leq 4$ per day	5-6
$n \leq 2$ per hour and > 4 per day	4
$2 < n \leq 10$ per hour	3

5. CIVIL SCOPE OF SUPPLY & SERVICES

EFL has completed the Topographical Survey and Geotechnical Investigation for the project site. The corresponding reports are provided for reference and are attached as Annexure 1 and Annexure 2, respectively.

Notwithstanding the information provided, the EPC Contractor shall, at its own cost and responsibility, conduct such additional or independent Topographical Surveys and/or Geotechnical Investigations as may be considered necessary for the design, detailed engineering, construction, and successful execution of the Works.

The EPC Contractor shall be solely responsible for verifying the site conditions and for ensuring the adequacy, accuracy, completeness, and suitability of all designs and engineering deliverables. Reliance on the information provided by EFL shall not relieve the EPC Contractor of any obligations or liabilities under the Contract.

The scope and requirements of the surveys and investigations are specified in the subsequent sections of this Tender Document.

5.1 TOPOGRAPHY SURVEY AND SOIL INVESTIGATION

The Bidder shall carry out the Topographical Survey for the allocated project area, primarily using LiDAR-based survey methodology in accordance with this Technical Specification. LiDAR shall be the preferred method for acquiring topographical data for the project.

If the LiDAR survey cannot be carried out, either wholly or partially, due to non-availability of statutory or regulatory clearances, operational limitations, inaccessible terrain, adverse site conditions, or any other justifiable reason, the Bidder shall submit adequate justification and obtain prior written approval from the Owner. In such cases, the Topographical Survey shall be carried out in accordance with the requirements specified in the subsequent sections of this Technical Specification. The survey data shall be integrated to produce a single, seamless, and accurate topographical dataset for engineering, design, and construction purposes.

a) **LiDAR-Based Topography Survey**

Introduction

This document outlines the scope of work for conducting LiDAR-based topographical surveys. The survey aims to capture high-resolution topographical data for planning, design, engineering, and development of the proposed Solar PV, Wind, Floating Solar, and BESS facilities.

Scope

The Bidder shall carry out a detailed topographical survey of the entire project area and prepare all survey plans, maps, drawings, digital models, and survey reports. The survey shall be performed using UAV-mounted LiDAR sensors capable of achieving the specified point density and survey accuracy. The scope shall include the collection of all field data and the preparation of survey drawings showing the longitude, latitude, and elevation of all boundary corners, control points, permanent benchmarks, reference pillars, and other strategic locations. The complete survey report, along with all processed and raw survey data, shall form part of the deliverables.

The Bidder shall establish permanent benchmarks and reference pillars at suitable locations throughout the project area. The locations of all benchmarks and reference

pillars shall be clearly indicated on the survey drawings along with their coordinates and reduced levels. The survey shall be carried out in the Universal Transverse Mercator (UTM) coordinate system using the specified project datum and coordinate reference system. Survey grids shall be established in the North-South and East-West directions corresponding to the project grid or magnetic north as specified. The survey shall also cover a minimum width of 50 m beyond the project boundary to facilitate correlation with adjoining land parcels and surrounding topographical features.

The survey shall establish the horizontal and vertical positions of all existing natural and man-made features within the survey limits. These features shall include rivers, streams, canals, drains, ponds, lakes, roads, culverts, bridges, footpaths, boundary walls, fences, buildings, electric poles, transmission lines, communication towers, substations, switchyards, pipelines, utility corridors, and other permanent structures. The survey shall also capture trees, cultivated areas, forest patches, and other significant vegetation. All features shall be represented on the survey drawings using standard engineering symbols, preferably in accordance with Fiji Lands Department mapping conventions or generally accepted international GIS mapping conventions. Terrain elevations shall be represented through suitable contour intervals to accurately depict hills, valleys, ridges, depressions, and other ground features. All trees shall be identified, numbered, and tabulated. The location of each tree shall also be marked on the survey drawings.

In areas with steep slopes, dense vegetation, waterlogged ground, inaccessible terrain, or other locations where conventional survey methods are inadequate, the Bidder shall adopt suitable survey techniques to achieve the specified accuracy and complete data coverage. The Bidder shall identify, survey and clearly indicate all unusual ground conditions and significant topographical features encountered during the survey. These shall include exposed rock outcrops, escarpments, natural depressions, springs, waterfalls, drainage channels, water bodies, erosion-prone areas, borrow areas, potential aggregate deposits and any other natural or artificial features that may influence the planning, design, construction, operation or maintenance of the project.

The Bidder shall prepare and submit topographical survey maps at a scale of 1:10,000 showing the established survey grid, contour lines and all permanent and significant site features. The drawings shall clearly identify roads, railways, waterways, canals, drains, culverts, bridges, buildings, villages, settlements, places of worship, burial grounds, boundary walls, fences, transmission lines, substations, switchyards, communication towers, existing benchmarks, pipelines, overhead and underground utilities where identifiable, access roads, embankments, rocky outcrops, forest areas,

ponds, lakes, reservoirs and all other natural or man-made features that may affect the project. The survey maps shall be prepared in digital format using AutoCAD Release 2016 or later version or equivalent engineering software.

Bidder shall submit all survey drawings in original editable AutoCAD (.dwg) format and PDF format. The complete survey database, including point cloud data, contour data, coordinate data, levels, control point information, DEM, DTM, Orthomosaic, and array layout, shall be submitted in editable digital format with X, Y and Z coordinates. Three copies of the complete digital data shall be provided in external hard drives/USB storage devices.

Bidder shall generate final deliverables in AutoCAD-compatible formats, along with Digital Terrain Models (DTM), Digital Surface Models (DSM), contour maps, and other terrain products derived from the LiDAR survey. High-resolution orthophotos shall be generated by integrating the LiDAR data with the acquired RGB aerial imagery. The orthophotos shall be accurately georeferenced and suitable for engineering design and project planning. The scope shall also include tree enumeration and vegetation classification within the project area. Vegetation parameters, including tree height, canopy diameter, canopy cover and canopy gaps, shall be assessed using LiDAR data supported by field verification wherever required. The Bidder shall construct all permanent benchmarks and reference pillars as part of the survey work and shall submit their coordinates, elevations and construction details along with the final survey documentation.

Working Principle

LiDAR (Light Detection and Ranging) technology uses laser pulses to measure distances to the Earth's surface. The system emits laser pulses, which reflect off the ground and return to the sensor. The time taken for the pulses to return is used to calculate the distance, creating a precise 3D map of the terrain.

The LiDAR survey shall achieve a minimum point density of 20 points/sq. m over the entire survey area. The Bidder shall increase the point density wherever required to maintain the specified survey accuracy and ensure complete coverage of complex terrain, vegetation, structures, or other site conditions. The selected flying height, flight speed, and scan parameters shall be suitably planned to achieve the required point density and data quality throughout the project area.

The objective of the LiDAR survey is to obtain accurate, reliable and high-resolution topographical information for the entire project site. The processed LiDAR data shall

be used to generate Digital Elevation Models (DEMs), Digital Terrain Models (DTMs), Digital Surface Models (DSMs), contour maps, and other terrain products required for engineering design and project planning. The generated datasets shall maintain uniform quality, completeness and consistency throughout the survey area. The data shall be suitable for detailed engineering, earthwork assessment, drainage analysis, project layout optimisation and construction planning.

The LiDAR system and the complete survey methodology shall achieve the following minimum accuracy requirements:

- Horizontal Accuracy: ≤ ±100 mm
- Vertical Accuracy: ≤ ±50 mm
- Point Density: Minimum 20 points/m^2
- Accuracy Validation: Through Differential Global Positioning System (DGPS) survey using Ground Control Points (GCPs) and independent Check Points (CPs)

The LiDAR survey shall be planned, executed, and processed in accordance with the latest applicable standards of the American Society for Photogrammetry and Remote Sensing (ASPRS) for digital geospatial data and the relevant provisions of the USGS LiDAR Base Specification. All survey equipment shall be properly calibrated, and all processing workflows shall follow recognised industry best practices to ensure reliable and repeatable survey results.

The integration of LiDAR data with Geographic Information System (GIS) platforms shall comply with the applicable requirements of ISO 19130 or equivalent internationally recognised geospatial standards. The processed datasets shall be compatible with standard GIS and CAD software for engineering applications. All coordinate systems, reference datums, metadata and data attributes shall be properly documented and maintained throughout the survey process.

The survey methodology, flight planning, control network, contour interval, data processing workflow, and accuracy requirements shall be submitted for review and carried out as approved by the Owner or Owner's Engineer. The final survey outputs shall satisfy the accuracy and quality requirements necessary for detailed engineering design and construction activities. The complete survey data shall be subject to review, verification, and acceptance by the Owner. The Bidder shall establish adequate Ground Control Points and independent Check Points to validate the survey

results. Detailed accuracy assessment reports, quality assurance records, and validation documents shall be submitted along with all survey deliverables.

The Bidder shall acquire high-resolution RGB aerial imagery simultaneously with the UAV LiDAR survey using a calibrated digital camera with a minimum sensor resolution of 24 MP. The camera shall be equipped with a global shutter to eliminate image distortion caused by UAV motion and to ensure accurate photogrammetric measurements. The imagery shall be captured under suitable lighting and weather conditions to maintain consistent image quality throughout the survey.

The acquired imagery shall be processed to generate a high-resolution orthophoto with a Ground Sampling Distance (GSD) not exceeding 3 cm/pixel. The image acquisition shall be planned with a minimum forward overlap of 80% and a minimum side overlap of 70%. These overlap requirements shall ensure complete ground coverage and provide sufficient redundancy for reliable image matching and orthophoto generation.

The orthophoto shall be accurately georeferenced to the project coordinate reference system using the UAV positioning data and the established survey control. The final orthophoto shall achieve a horizontal positional accuracy of not more than ±100 mm (RMSE). The accuracy shall be demonstrated through appropriate quality checks and validation against independent ground control points or check points wherever applicable.

The final Ortho mosaic shall be seamless and free from visible stitching artefacts. It shall be colour-balanced and consistent throughout the survey area. The Ortho mosaic shall provide continuous coverage of the complete project area and shall include a minimum buffer of 50 m beyond the project boundary on all sides. The final deliverable shall be suitable for engineering design, planning, construction activities, and project documentation.

Governing Authorities for Drone Surveys

The Bidder shall obtain all statutory approvals, permissions and clearances required for carrying out the UAV-based LiDAR and aerial imagery survey. The survey shall comply with the Civil Aviation Authority of Fiji (CAAF) laws, guidelines, and applicable Fiji regulations. The Bidder shall obtain any approvals required from authorities or any other competent authority at its own cost before commencement of the survey.

Where the project site falls within restricted, controlled, prohibited or other sensitive areas, the Bidder shall obtain all additional permissions required from the concerned authorities before undertaking the survey.

If the required permissions are not granted or drone operations are otherwise not feasible due to statutory or security restrictions, the Bidder may adopt conventional topographical survey methods only with prior written approval of the Owner's Engineer (OWNER'S ENGINEER). The alternative survey shall fully comply with the specified accuracy, quality and deliverable requirements of the Contract.

Deliverables

The following data shall be submitted and presented in the topographical survey report.

- High-resolution Digital Elevation Models (DEMs)
- Digital Terrain Models (DTMs)
- Digital Surface Models (DSMs)
- LiDAR point clouds and intensity data
- Survey report detailing methodology, equipment, and results
- Final outputs in AutoCAD format
- Topographic maps, Contour maps, Vegetation maps, 3D terrain models, Orthophotos
- Site photographs during the survey

Benchmarks and Survey Data Requirements

- Minimum two permanent benchmarks shall be provided. The permanent benchmark pillar shall be provided, on average, at an interval of 250 acres, or part thereof. However, the interval may vary depending on the type of land. For areas having hillocks, forest cover, water bodies, marshy land, etc., the interval can vary to accommodate workability. For areas that are comparatively flat and have sparsely located trees, the interval may be relaxed at the discretion of the Owner's Engineer.
- Permanent benchmark pillars shall be made from durable materials to ensure longevity and stability. The benchmark may be constructed using concrete, brick masonry, or stone pillars. The pillar shall extend to a minimum of 1000

mm below ground level and 500 mm above ground level, and shall be a minimum of 300 mm × 300 mm.

- The bidder shall decide and execute the level transfer methodology according to the prevailing site conditions and in accordance with the contract requirements.

The Bidder shall rectify any deficiencies in coverage, quality, or accuracy identified during review through re-survey, re-processing, or data correction at no additional cost to the Employer.

All raw and processed survey data, including LiDAR point clouds, orthophotos, DEMs, DTMs, DSMs, and CAD outputs, shall become the property of the Owner upon submission.

b) **TOTAL STATION BASED TOPOGRAPHICAL SURVEY**

TOPOGRAPHICAL SURVEY

The Bidder shall conduct the Topographical Survey for the allocated plot in the proposed solar project. The scope of work and technical specification for the same are as follows:

Scope of Work

The Bidder shall carry out the Topographical Survey and prepare plans (survey maps) and a report for the entire area to locate the Solar PV power plant and its other systems.

Carrying out the Benchmark ("Fiji Geodetic Datum", "Fiji Map Grid (FMG) benchmark", or a generic "National Survey Datum.") to site(s) under survey by parallel levelling, establishing and constructing benchmarks, grid and reference pillars in the field and spot level survey of the entire area at specified intervals and development of the contours. The bidder can also use DGPS for establishing the coordinates.

Carrying out a cross-section of the river/canal, taking spot levels at an average of 20-meter intervals or less, depending upon the site conditions.

Furnishing all field data and drawings with the longitude and latitude of all corners and strategic points, as well as the survey report described in detail in the succeeding paragraphs, is also included in the scope of this work.

The work shall include the construction of two permanent Benchmarks and reference pillars, as shown on the survey drawings.

Latitude and Longitude: The work shall be carried out in the UTM grid system.

At least a 50 m width of the adjoining solar plots and area shall also be covered in the survey for correlation with adjoining plots. The presence of any well and/or tube well at the site or in adjoining areas, and the water level in them, shall be marked in the documents/drawings.

Topographical Survey and Mapping

The positions, both in plan and elevation, of all natural and artificial features of the area, such as waterways, trees, cultivation, houses, fences, sealed and unsealed roads including culverts and crossings, foot tracks, and other permanent objects such as telephone posts and transmission towers, etc., shall be established and subsequently shown on survey maps using conventional symbols (preferably in accordance with Fiji Lands Department mapping conventions or generally accepted international GIS mapping conventions). All hills and valleys within the area(s) shall be surveyed and plotted on maps by contours.

The method of the survey, contour intervals, etc., shall be decided by the bidder with the prior approval of the Owner, in cases of steep slopes and dense jungle, where grading is not possible. Any unusual condition or formations on the ground, locations of rock outcrops (if visible on the surface) and springs/falls, possible aggregate deposits, etc., shall also be noted and plotted on the maps.

The field work shall be done with Total Station Equipment in the following steps:

Establishing horizontal and vertical controls and locating reference grids and benchmarks in the area. Surveying for establishing spot levels and plotting contours. Surveying for locating the natural and artificial details as described earlier.

The grids for the survey work shall be established in N-S & E-W direction (Corresponding to Magnetic North).

Contouring

The Bidder shall carry out spot-level surveying at an average interval of 10 m for contouring the area. Levels shall also be taken on all traverse stations and on salient

points located at random over the area (ground points). Contours shall be interpolated at 0.5 m intervals after the above points are plotted.

Preparation & Submission of Survey Maps and Documents

The Contractor shall submit survey maps of the site at a 1:10,000 scale, indicating grid lines and contour lines and demarcating all permanent features such as roads, waterways, buildings, power lines, natural streams, trees, etc. All maps shall be prepared in digitised form using computer software such as AutoCAD Release 2016 or later.

The Bidder shall submit all survey data and the array layout in original editable formats (.dwg and .pdf), including all levels and coordinates in X-Y-Z format for the entire area, in scale, in soft copy and hard copy (three copies in A0 size).

5.2 GEOTECHNICAL INVESTIGATION SCHEME

a. The scheme for geotechnical investigation shall be as given in Clause 2.1 and shall be approved by the Employer before execution. The Bidder shall carry out a geotechnical investigation for establishing the sub-surface conditions and to decide the type of foundations for the structures envisaged, construction methods, any special requirements/treatment called for, remedial measures for sub-soil/ foundations, etc., in view of soft sub-soils, aggressive sub-soils and water, expansive/swelling soils, etc. prior to commencement of detailed design/drawings.

   The Bidder shall obtain the approval for the field and laboratory testing scheme before undertaking the geotechnical investigation work.

b. The detailed Geotechnical Investigation has to be carried out by the bidder in line with the Technical Specification. Bidder shall carry out the design of the foundation, etc., based on the approved geotechnical report.

c. Field test shall include, but not be limited to, the following:

   Boreholes, Standard Penetration Test (SPT), collection of disturbed and undisturbed soil samples (UDS), Trial Pits (TP), collection of water samples, Electrical Resistivity Test (ERT), etc.

d. Bidder shall carry out its own Geotechnical Investigation, as per the requirements of the Technical Specification provided at Cl. 5.2.1 below. No time extension would be admissible on account of this.

Bidder shall carry out the design of the foundation, etc., based on the approved geotechnical investigation report.

5.2.1 Scheme of Geotechnical Investigation

Minimum 1 No. A borehole of 5 m depth shall be carried out in every 12.5 acres of land. Minimum 1 number of ERT & 1 no TP shall be carried out for every 100 acres or less area, as per the layout.

The depth of the borehole at the Control Room Building shall be at least10 m, and that at the Switchyard location shall be at least 12 m, or the depth of the borehole at these locations shall be as per the approved geotechnical investigation scheme.

SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery upto 20%, met within a borehole. This test shall be conducted at every 1.5 m interval or at the change of strata. The starting depth of SPT shall be 0.5m from ground level. UDS shall be collected at every 1.5m interval or at the change of strata. If UDS cannot be collected, the SPT interval shall be reduced to 1m instead of 1.5m.

The laboratory tests shall be conducted on soil, rock & water samples collected during field investigations in sufficient numbers. Laboratory tests shall be carried out on disturbed and undisturbed soil samples for Grain Size Analysis, Hydrometer Analysis, Atterberg Limits, Triaxial Shear Tests (UU), Natural Moisture Content, Specific Gravity and Bulk Unit Weight, Consolidation Tests, Unconfined Compression Test, Free Swell Index, Shrinkage Limit, Swell Pressure Test, Chemical Analysis test on soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, organic matter and any other chemicals harmful to concrete and reinforcement/ steel. Laboratory tests on rock samples shall be carried out for Hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (in-situ & saturated), Slake Durability etc

On completion of all field and laboratory work, the Bidder shall submit a Geotechnical investigation report for approval. The Geotechnical investigation report shall contain field and laboratory observations/ data/ records, analysis of results and recommendations on type of foundation for different type of structures envisaged for all the areas of work.

Recommendations on treatment for soil, foundation, based on subsoil characteristics, soft soils, aggressive chemicals, expansive soils, etc. shall also be covered in the report, as applicable.

Prior approval of Owner shall be taken for engaging agency for Geotechnical investigation works.

5.2.2 Foundation System

Foundation system for various facilities shall be designed and adopted as per approved geotechnical investigation report and relevant AS/NZS. The general requirements for the foundation system to be adopted, are as given below.

a) All structures/ equipment shall be supported either on a suitable open foundation (isolated, combined, raft) or a pile foundation, depending on the type of structures/ facilities, sub-strata, topography, etc.

b) If the encountered sub-strata are "expansive clay soil" or "highly reactive clay," the same shall be either replaced up to the full depth of "expansive clay soil" or "highly reactive clay," or expansive soil shall be stabilised by suitable treatment.

c) Shallow foundation shall not rest in **"expansive clay soil"** or **"highly reactive clay."**

d) All foundation systems shall be designed in accordance with the latest revisions of relevant AS/NZS Standards (such as AS 2159 for piling and AS 3600 for concrete). For short pile foundation, method by B. B. Broms shall be followed for calculating lateral resistance and lateral deflection of a pile.

e) Contractor shall furnish design of piles for approval.

f) Level of Ground water table for design purpose shall be considered as per the recommendation of geotechnical investigation report.

g) Minimum depth of foundation shall be 1.2 m below ground level.

h) In areas where sand erosion is anticipated, depth of pile shall be increased beyond designed depth by minimum 300mm or envisaged depth of erosion, whichever is higher.

i) Testing of piles and interpretation of pile load test results shall be carried out as per the stipulations of AS 2159 . Contractor shall obtain approval for the pile load test scheme before undertaking the pile load test.

j) In case of filling at any location, pile length shall be increased up to the extent of filling height.

5.2.3 Rammed Steel Pile as MMS foundation for Ground Mounted solar PV Projects

Considering the substrata condition, advanced and mechanized steel pile foundations may be opted for MMS of a solar PV system:

Rammed Steel Pile

Ramming as a technology is widely used across the globe for solar foundation installation purpose, and now is being adopted widely. The purpose is to reduce the project execution time as well as to encourage new technology with advanced solution in the solar projects. Under the ramming technology, a galvanized iron post (AS/NZS structural profiles) is hammered/rammed into the strata till a certain depth, depending on substrata condition and structure load, in order to gain the required load carrying capacity of the pile. To avoid the corrosion in the steel section, due to continuous impact of water and air, or due to aggressive chemical environments, suitable anti-corrosive measures need to be considered.

A dolly/ cushion of hardwood or some suitable material is placed on top of the steel pile to receive the blows of the hammer and hence to avoid damage to pile head. The stroke/drop of hammer shall preferably be limited to 1 - 1.5m, as per the drivability study and weight of hammer available. Pile shall be installed vertical, as accurately as possible. As a guide, for vertical piles, an angular deviation of 1.5% should not normally be exceeded. Pile should not deviate 50 mm or D/6 (D would be depth of section in case of Universal Beams (UB) or Parallel Flange Channels (PFC) whichever is less.

A pile cap should be cast by concrete of min. N25 grade having projecting length 150 mm above the ground level and minimum 250mm below the ground level to minimize

the corrosion in the steel section. Length and other parameter of pile can be decided by performing the pile load tests and applying a suitable factor of safety as per code/ approved methodology.

Condition favourable for Rammed Steel Pile: -

a) All kinds of soil, particularly in sand where installation of bored pile is challenging due to collapsible nature of the soil.

b) Driven piles are most appropriate where soils are firm and compacted, with enough fine-grain materials as it further densifies the surrounding medium.

Conditions Adverse to/ Special Precautions to be taken for Rammed Steel Pile: -

a) May not be suitable in soil and/ or ground water, having aggressive chemical contents that is corrosive conditions (site categorizes in "Severe" or "Very Severe" as per Section 6 of AS 2159).

b) Suitability of driving method should be properly assessed in hard/rocky strata.

c) Damage of head of steel pile and buckling of long steel section while driving the steel section, in case of long pile/ hard driving.

d) Considering the driving method and substrata condition, the galvanised coating may get scratched/ removed while driving, posing risk of corrosion.

e) Steel pile section may get deflected/ damaged due obstructions at toe while driving.

f) Length and cost overruns may occur when used as a friction pile.

g) Thickness of steel section which is part of main leg of MMS is more when compared to normal bored concrete piles.

If Bidder choose to provide Rammed Steel Pile after due consideration to the above criteria, then following shall be adhered to by the bidder w.r.t Corrosion Protection.

Steel Section shall be designed considering minimum 120micron thick galvanization in HDG Piers and while deciding the thickness of section corrosion allowance shall be considered.

The decision on the possibility of use of Rammed Steel Piles, depending on the substrata condition, is subject to the approval of the Owner's Engineer.

5.3 SITE LEVELLING AND GRADING

5.3.1 SITE LEVELLING AND GRADING:

Site levelling works involves the following works:

a) Site levelling works/scheme shall match with the specific functional requirement of Solar PV optimum generation considering the full utilization of the plot area for the desired capacity.
b) Site grading level shall be fixed with due reference to site drainage of the whole area, existing drainage pattern and system requirements.
c) For Plant boundary wall and fencing.

Based on the spot level, contour survey done and meeting above requirements, bidder can propose different site grade levels. The site levelling may be carried in patches/blocks. Bidder may also propose the site leveling and grading matching with the natural topography of the land considering the optimized use of the land, however bidder shall ensure to meet the desired power generation capacity in the allotted plot area. Bidder shall also ensure that no water ponding and flooding occurs in the low-lying areas & effective drainage is provided in the whole plot area, in all kind of site levelling and grading or plant at natural topography schemes, bidders has to provide proper and effective drainage system in line with “Drainage System” chapter. After performing the optimization of levels from the detailed site survey by the Bidder, the final formation level of the plot in various areas shall be finalized. The area shall be suitably cut and filled to suit the layout requirement. The site levelling and grading scheme incorporating the above aspects shall be submitted to Owner for prior approval.

Fill shall normally be made up of cohesive, non-swelling material capable of being compacted up to 95% of Maximum Dry Density (MDD) in accordance with AS 1289 / AS 3798. If cohesionless soils (Sandy soils) are used as fill material, then the degree of compaction shall be 75% of relative density for site levelling and grading work.

In case earth has to be borrowed from outside the plant boundary, the same shall be arranged by the Bidder. The slope at the edge of graded areas shall not be steeper than 1:1.5 (1 vertical to 1.5 horizontal) in cutting and 1:2 in filling.

All buildings & switchyard area/sub-station area shall be constructed in levelled area. No foundation shall be allowed on back filled soil and in that case the depth of foundations shall reach up to NGL. Final Level will be approved in detail engineering.

The slope protection measure shall be provided in case inter levelled patches level difference is more than 2.0m. Random rubble/boulder/stone pitching/concrete blocks etc. shall be provided for the slope protection for roadside slope, storm water ditches/drainage, embankment slopes, inter levelled patches slopes etc. as per design requirements.

Suitable sand/soil erosion control measure shall be provided in case any loose soil areas fall inside the plot area. The same may be made with Random rubbles/boulders/stone pitching/concrete blocks/ engineered fill, lateritic gravel, or crushed rock filling, etc. Bidder shall also provide sufficient grass/buses/trees covers on these loose soil patches, as specified below for desert areas.

Bidder shall also provide suitable erosion protection measure around the foundation as mentioned above. In case engineered fill, lateritic gravel, or crushed rock filling around foundation is adopted as erosion measure, then well compacted engineered fill, lateritic gravel, or crushed rock filling around foundation/ pile may serve the purpose of control of sand erosion. However, diameter of extent of engineered fill, lateritic gravel, or crushed rock layer shall be at least 1500mm beyond face of foundation and depth of filling shall extend at least 100mm beyond the maximum depth of erosion observed/ anticipated. In no case, it shall be less than 300mm.

5.4 BOUNDARY WALL, FENCING AND GATE

5.4.1 General

The scope of work includes providing either or combination of following as per scope defined in Vicinity Map/Appendix-D1 (General design data for Solar PV Site) of the proposed Solar Plant for the peripheral and common boundary.

a) Chain Link Fencing

As per Tender Drawing Title: Details of Chain-link fencing

Chain Link Fencing for Yard (Transformer Yard, Metering Yard, etc.)

As per Tender Drawing Title: CHAIN LINK FENCING FOR YARD AND COMMON FENCING

Main Gate

A 4 m wide double-leaf swing gate fabricated from C-Grade galvanised steel shall be provided. The gate shall consist of a mild steel frame infilled with chain-link mesh and shall conform to AS/NZS 3679.1 or AS/NZS 3678, as applicable. The gate shall be complete with all necessary fittings and fixtures, including hinges, locking arrangement, gate stops, latches, posts, and other accessories required for proper operation. The width of the approach road at the main entrance shall match the gate opening width with suitable transitions. All gate components, including posts and fittings, shall be manufactured from galvanised steel, and any cut edges, welds, or damaged galvanised surfaces shall be repaired in accordance with the relevant Australian Standards.

For finishing coat suitable colour pigment shall be added. All paints including primer shall be of reputed brand/manufacturer and as approved by the Owner's Engineer. The method of application shall be as per the recommendations of the manufacturer.

One person movement passage gate (minimum 1.2m width) shall also be provided at the main entry gate. 400 mm height concertina with all supporting members shall also be provided on a gate (gates other than main entry gate) for better security.

The minimum size & requirements of the Gate's including all items shall be as per the fencing tender drawing title: "Details of Main Gate".

The main gate shall be constructed inside the plant/plot boundary line to provide sufficient space for Heavy motor vehicle and light motor vehicle for inspection/check before entering the solar plant and vehicles shall not disturb the traffic in the main approach road.

HT cable support

As per detailed Engineering, if overground cabling is envisaged to avoid submergence during flooding, following would be followed for overground support.

T-TYPE RCC Pedestals or Galvanized Steel Structure Over Concrete Pedestals shall be constructed for laying of the HT cable from Transformer to 33kV switchgear. Height of such structures would be as per Electrical Cabling – Technical Requirement (System Design), w,r,t Flood Level Report.

5.5 DESIGN OF MODULE MOUNTING STRUCTURE & CIVIL WORKS

Design criteria for module mounting structure (MMS)

The design calculations and drawings for MMS shall be submitted for prior approval of Owner before the commencement of construction. The construction methodology for MMS (Fixed Tilt mechanism) and its foundations shall be submitted for Owner's approval before the start of works. The module mounting structure should be hot dipped galvanized with minimum coating of 120 microns.

The following is the minimum design Service Conditions applicable in Fiji Islands:

Parameter	Value
Daily Average Ambient Temperature	**32 °C**
Maximum Ambient Temperature	**40 °C**
Annual Average Ambient Temperature	**33 °C**
Minimum Ambient Temperature	**15 °C**
Relative Humidity	**85%**
Altitude	**100 m**
Maximum Wind Speed (under cyclonic conditions)	**85 m/s**
Importance Level	**4**
Isokeraunic Level	**50**
Seismic Level	**6 on the open-ended Richter scale**
Average Annual Rainfall	**2,763 mm**

Scope:

This section covers the loads and design requirement of the structures, racking, and all other items required to furnish and install a complete ground mounting structural system which constitutes a photovoltaic array(s).

Design Loads:

a) Dead Load: The load obtained by summing up the weight of modules and self-weight of Structure including Purlins, rafter/beams, Bracings, struts, columns, necessary fittings, etc. to be added as a Dead load.
b) Wind Load: The wind load (positive and negative) normal to surface on the modules and wind load on the structural members.
c) Refer Technical specification for site-specific design parameters.
d) The concept of wind tunnel studies may be considered in the design philosophy for fixed /seasonal module mounting structure.

If the Bidder is going for wind tunnel study for the design and analysis of complete MMS, it must be done from an institute of repute having suitable wind tunnel facility. This study will be witnessed by EFL's Two (2) representatives, All the cost associated with this including transportation, accommodation, flight and meals shall be paid by the bidder.

Design Parameters:

a) MMS design & analysis is to be done on computer software (preferably STAAD) and the Bidder shall submit a write-up on the computer program used and its input (soft format) and output data for review and approval.
b) An increase in allowable stresses of structural materials should not be considered during design and analysis.
c) Wind pressure for following loads shall be considered as follows:

   (1) Dead Load of steel with all members, fittings & panels.

   (2) Load due to fair wind direction on design tilt angles of solar mounting structural members.

   (3) Load due to adverse wind direction on design tilt angles of solar mounting structural members.

(4) Load on the side face of mounting structural members.

d) Wind pressure coefficient, load and load combination shall be as per AS/NZS 1170.2 (latest revision).
e) Design analysis and the forces on MMS (Compressive force, uplift force, shear and moment) shall be used for the design of foundation system.
f) If Seasonal Tilting MMS type are proposed: Mechanized arrangement for lifting MMS during seasonal tilting shall be provided with MMS. The lifting forces shall be transferred only through rafter/beam for lifting the MMS during seasonal tilt with a suitable hook, clamp, etc. and fixed at rafter/beam.

Vertical Deflection and Horizontal Sway Limits:

Limiting Deflection: The limiting permissible vertical deflection for structural steel members shall be as per following:

a) Maximum vertical deflection in purlin = Span / 180,

b) Maximum vertical deflection in rafter (cantilever span) = Span / 180 and

c) Maximum lateral deflection in column/vertical post = Height / 240

d) All deflection limits can also be as per the serviceability limit defined by the module manufacturer & tracker manufacturer OR the proposed deflection limits duly approved by the module manufacturer during detailed engineering.

Materials Specification & Coating for Structural Steel Works:

Column/ Vertical Post	**AS 4100/ NZS 3404/ AS/NZS 4600.**	**250**	**70 micron (minimum)**	**2.0**	**110 micron (minimum)**	**3.0**
Bracing/Rafter/ Beam/Purlin				2.0		
Steel Tubes in all sections	AS 4100/ NZS 3404/	240		2.0		

	AS/NZS 4600.					
Hollow Steel in all sections	AS 4100/ NZS 3404/ AS/NZS 4600.	240		2.0		
Coupler/Plate /Cleat Splice/Sag Angle	AS 4100/ NZS 3404/ AS/NZS 4600.	250		2.0		2.0
		Yield strength, MPa	**Coating Class Designation**			
Rafter/ Beam/ Purlin (Pre-Galvanized steel sections)	AS/NZS 4680	255-550	Z600	1.6	Not recommended in coastal areas	
NOTE:	1. Minimum elongation % shall be as per relevant Standard and Code. 2. Materials shall be fabricated in the shop. 3. Minimum coating requirement mentioned above in the table. 4. All structural calculations of cold formed steel section for checking the adequacy for strength and deflection criteria is to be done taking into consideration the maximum permissible negative tolerance over specified BMT i.e, the lower limit of BMT is to be considered.					

	5. The tolerance on Base Metal Thickness (BMT) thickness of steel shall be as given in AS/NZS 1365 (Tolerances for flat-rolled steel products).

B. Hot-dip Aluminium-Zinc alloy metallic coated sheet steel strip and sheet sections:

Members	**Reference code**	**Yield strength, MPa**	**Coating Class Designation**	**Min Thickness (mm)**	**Coastal Area***
Rafter/ Beam	AS 1397	250 - 550	**AZM 165** (ASTM A792M) /AS1397) OR ZM165 confirming to AS 1397 for Corrosion category C-5 & for 25 years of corrosion warranty	**1.2**	**Not recommended in coastal areas**
Purlin	AS 1397	250 - 550	**AZM165** (ASTM A792M) / AS 1397) OR ZM165 confirming to AS 1397 for Corrosion category C-5 & for 25 years of corrosion warranty	0.9	Not recommended in coastal areas

NOTE:	1. Minimum elongation % shall be as per relevant Standard and Code. 2. Materials shall be fabricated in the shop. 3. Minimum coating requirement mentioned above in the table. 4. All structural calculations of cold formed steel section for checking the adequacy for strength and deflection criteria is to be done taking into consideration the maximum permissible negative tolerance over specified BMT i.e, the lower limit of BMT is to be considered. 5. The tolerance on Base Metal Thickness (BMT) thickness of steel sheets and coils shall be as given in the relevant AS/NZS equivalent

*Painting of Steel Surfaces embedded in Concrete : For the portion of Steel surfaces completely embedded in Concrete as reinforcement or otherwise for foundation systems, the surface shall be prepared by Manual Cleaning and provided with Primer Coat of Chlorinated Rubber based Zinc Phosphate Primer of Minimum 50 Micron Dry Film Thickness (DFT).

C. Bidder shall also use principles governing design that shall prevent or reduce the risks of corrosion as per AS/NZS 2312.1 and AS/NZS 2312.2 and other relevant codes.

Connections**:**

Sl No	Connection	Grade
1	Solar PV module to purlin/structure connection.	SS304, A2-70

2	Bolts required to loose and tighten seasonally for seasonal tilting in the module mounting structure.	
3	Other structural fixed connections.	HDG 5.6 & 8.8
4	Foundation Anchoring.	HDG 4.6

Note: Fastener shall conform to 'AS 4291.1' / 'AS/NZS 1252' / 'AS 1111' / 'AS 1112'

a) SS304 Fasteners (nuts, bolts, washers and U-bolts) shall be of corrosion-resistant austenitic steel. SS 304 Fasteners shall have a good anti-seize finish with proper wax coating for better durability and firm resistance to all types of failure including seasonal removal and re-fixing of bolts.

b) All fasteners shall be provided according to the connection design requirement. All bolts shall be tightened with designed torque mechanically immediately after the erection of MMS to avoid any possible damage due to any incidental storm during the erection stage.

c) One set of fasteners shall consist of one hexagonal head nut, one hexagon shape bolt, and two washers. The bots and nuts with inbuilt washers may also be provided.

d) In the ground mounting structure system with seasonal tilt arrangement, the column post and rafter/beam at seasonal tilt point of rotation shall be preferably hinged plate and bolt system.

Foundation System

Top of concrete/ height of collar for MMS foundation shall be minimum 250mm above Finish ground level. The proposed foundation system for MMS shall be based on findings/results of the approved geo technical investigation report. Following kind of foundation may be provided:

1. Short pile foundation (Min. 300mm dia.)
2. Rock anchor with concrete collar (Min. 700 sq.cm.)
3. Isolated, strip or raft foundation
4. Concrete ballast foundation

List of applicable standards

AS/NZS 3679.1	**Structural steel - Hot-rolled bars and sections**
AS/NZS 4600	Cold-formed steel structures
AS/NZS 1163	Cold-formed structural steel hollow sections
AS/NZS 1163	Cold-formed structural steel hollow sections
AS/NZS 4680	Hot dip galvanized (zinc) coatings on fabricated ferrous articles
AS/NZS 4792	Hot dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialized process
AS 1231	Aluminium and aluminium alloys - Anodised coatings for architectural applications
AS/NZS 4680	Hot dip galvanized (zinc) coatings on fabricated ferrous articles

AS 1397	Continuous hot-dip metallic coated steel sheet and strip
AS/NZS 2312 Series	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
AS2067	Substations and high voltage installations

5.6 CIVIL & STRUCTURE WORKS - GENERAL DESIGN CRITERIA

5.6.1 GENERAL

The layout, design and drawings for Buildings, Structure and foundation system shall be approved from Owner before the start of works. Design of RCC and Steel structures shall be carried out as per AS 3600 / NZS 3101 & AS 4100 / NZS 3404 respectively. Refer appendix-D1 for site specific design parameters.

5.6.2 INVERTER ROOMS & SECURITY ROOM

The following structures shall be designed and provided by the bidder:

CMCS Buildings: For the operation and maintenance of SPV Plant one Central Monitoring and Control Station (CMCS) building shall be provided. The CMCS building shall consist of the following as minimum:

a) CRP/SAS Panel Room
b) Electrical Lab
c) Maintenance Staff Room
d) Storeroom
e) ACDB/DCDB Room
f) Battery Room
g) Toilet (Ground Floor) - 1 x Male with Urinal & 1 by Female.
h) Corridor
i) SCADA and SAS Control Room
j) Pantry Cum Dining Area
k) Conference Hall
l) 33 kV Pooling Switchgear Room/Building
m) Panoramic observation deck on terrace of CMCS building.

Bidder to adhere to the Tender Drawing and equipment's manufacturers requirements for development of layout. The CMCS shall be RCC framed structure with bricks/concrete blocks masonry walls. Steel Frame (instead of RCC) with Brick Walls is permitted as an additional option. The CMCS shall have entry lobby and portico with a roof for vehicle stoppage.

Parking shed to accommodate at least 6 cars shall be provided near the CMCS building with arrangements for Charging of EVs. The parking shed shall be made of structural

steel conforming to AS/NZS 1594 & AS/NZS 3679.1 (for sections) with permanently color coated roof sheets. The minimum size & requirements of the CMCS Building & all items shall be as tender drawing title: "Details of Central Monitoring & Control Station".

Inverter Rooms: Inverter rooms consist of PCU's, LT panels, batteries, etc. shall be provided based on manufacturer recommendation, easy passage of O&M persons and cable trench layout required.

The inverter rooms shall be made through any of the options as mentioned below:

a) RCC framed structure with bricks/concrete blocks masonry walls,
b) Pre-Engineered Building in line with PEB Tender drawing & technical specification (IR PEB shall be provided only in **non-coastal area**),
c) Steel Containerized solutions.
d) Structural elevated shaded platform on RCC/Pile Foundation.

The battery and its associated equipment shall be suitably segregated inside the Inverter room with proper ventilation arrangement. The battery room floor finish to be an epoxy coated floor which should have minimum of 15 to 30 mils (0.38 mm to 0.76 mm) thick for a standard high-build chemical-resistant. The room should have AC system for cooling with 1 x stand by unit.

The equipment inside the inverter room should be placed to provide sufficient space for their maintenance.

Security Room

A security room with a minimum floor area of 3 m × 3 m, including toilet facilities, shall be provided. The Contractor shall propose the type of construction (prefabricated, containerized, or brick/stone masonry with RCC roof slab) and the location of the security room, subject to approval of EFL. For containerized units, the toilet facility may be incorporated within the security room.

Store Room (PEB): One store shall be constructed for storage of Mandatory Spares during O&M Period by bidders and later on for Owner after O&M period. The store shall have rolling shutter of proper width for entry with proper ramp & and shall have lock and key arrangement. The store shall be of min. 250 sq. mtrs.

The buildings and allied works shall be designed to meet **Fiji National Building Code (FNBC)**/NCC (Australia) / NZBC (New Zealand) requirements. Finish floor level of all building/rooms shall be minimum 450 mm above from Finish graded level.

All railings in CMCS Building, Inverter rooms and other buildings shall be made of Stainless steel.

SPECIFICATION FOR (CENTRAL MONITORING AND CONTROLS STATION (CMCS) BUILDINGS AND OTHER RCC/MASONRY STRUCTURE.

The CMCS building shall be made of RCC framed structure with bricks/concrete blocks masonry walls. Any building including CMCS if made of RCC framed structure with bricks/concrete blocks masonry walls will be made in line with provisions of AS 3600 / NZS 3101. The thickness of outer masonry walls shall be minimum 230mm in case of bricks and minimum 200mm thick in case of concrete blocks. The roof shall be designed for a minimum superimposed load to 200 kg/m2. The bidder shall also provide rainwater harvesting system at all RCC building roofs (if provided).

SPECIFICATION OF INVERTER ROOMS (PEB):

The Inverter Rooms shall be made of Pre-Engineered Buildings (PEB). The architectural and civil works drawing of Pre-Engineered - Inverter Rooms are provided in the technical specification, tender drawings. Bidder shall prepare the detailed fabrication and civil construction drawings based on tender drawing title: “Pre-Engineered Building- Store Shed/Inverter Room” and submit to Owner for approval before the start of work. PEB shall be manufactured, supplied and erected by the bidder/PEB agency. The PEB shall be made of structural steel construction with double skinned metal roofing and wall cladding of approved profile. PEB shall be complete with painting, metal facia, metal gutter, rainwater down comers, sun-shades, openings, etc., along with associated structural steel, cladding and roofing work insulation, Trims & Flashings. Each item of PEB like panels, masonry, plastering, flooring, foundation, fittings etc. shall be suitable for the complete life of the solar plant. The construction methodology for PEB shall also be submitted for Owner approval before the start of works.

The layout of the Inverter room shall be designed so as to divert the heat generated from each inverter outside the room. The inverter room shall be designed for a life of 25 years. The PEB shall have a robust water tightness at all joints and connections. The building shall have a high-class durability and performance during the adverse weather conditions. The PEB supplied shall be complete in all respect meeting all the

requirements of tender drawings and other technical and functional requirements like lighting, ventilation system etc. to ensure effective functioning.

PEB length can be determined based on actual requirement, however, the grid spacing shall be maintained as per tender drawing title: “Pre-Engineered Building- Store Shed/Inverter Room”.

Structure and material specification:

The PEB inverter room structural members shall meet the requirements of tender drawings. All hot-rolled primary structural members and Rod/Angle/Pipe bracing, etc., shall conform to AS/NZS 3679.1, AS/NZS 3678, or AS/NZS 1163 (for pipe sections), minimum Grade 250. Secondary members for Purlins and Girts shall be designed in accordance with AS/NZS 4600 and manufactured from steel sheets conforming to AS 1397 (for metallic-coated) or AS/NZS 1594 (for uncoated), having a minimum yield strength of 345 MPa (e.g., Grade 350 or higher).

The minimum thickness of secondary members shall be 3mm. All other miscellaneous secondary members shall have the minimum yield strength of 250 MPa.

Insulated wall cladding or roofing shall consist of double skin metal cladding with Poly Urethane Foam (PUF). PUF must be made of continuous method PU foam and must be CFC free, self-extinguishing, fire retardant type with density 40 +/-2 kg/m3 and thermal conductivity 0.019-0.023 W/(m.K) at 10°C. The PUF panels shall be a factory made item ready for installation at site.

Fasteners & Connections:

Special coated self-drilling screws/fasteners shall be used conforming to Class 3 as per AS 3566.1 and AS 3566.2. General steel bolts, nuts, and washers shall comply with AS 1111 (Bolts), AS 1112 (Nuts), and AS 1237 (Washers).

High Strength Bolts for Primary Connections shall be Grade 8.8 conforming to AS/NZS 1252. Bolts for Secondary Connections shall be Grade 4.6 conforming to AS 1111 and AS 4291.1.

Anchor/foundation bolts shall conform to the mechanical properties of AS 4291.1 (minimum Property Class 4.6) and shall be detailed in accordance with the relevant provisions of AS 4100 and AS 3600."

Roof and Wall cladding:

PUF panels shall be made of troughed permanently colour coated metal sheets of steel for roofing and side cladding (internal and external) shall conform to the requirements for Hot-dip Zinc coated or Al/Zn coated sheets as per code. The insulation material thickness and details shall be as specified at the relevant para in the specification.

PUF insulated panels Metal Sheet for Roofing and side cladding consist of an external sheet as troughed permanently colour coated sheet & internal sheet as plain permanently colour coated sheet.

The chemical composition of Troughed permanently color metal sheet for roofing and side cladding shall conform to the provisions of same reference code to which the mechanical properties conform to.

Plain permanently color coated steel metal sheet for ridge and hips, flashing, trimming, closure for vertical and horizontal joints, capping etc. shall conform to the same requirements as those of troughed permanently color coated metal sheet for roof and side cladding.

The maximum spacing of the fastener shall be 390 mm c/c along the length of purlins/runners. However exact spacing shall be as per the design was done by the bidder of the fastener considering the wind load, self-load and other associated load. The minimum diameter of the fastener shall be 5.5 mm and at-lest 3 nos. of fastener shall be used per sheet.

Fillers blocks as a trough filler shall be used to seal cavities formed between the profiled sheet and the support or flashing. The fillers blocks shall be manufactured from black synthetic rubber or any other material approved by the engineer.

Roof Insulation and type:

Both metal sheets shall have an under insulation of minimum 40 mm thick PUF with density 40 +/- kg/m3 and thermal conductivity 0.019-0.023 W/(m.K) at 10°C with gutters and down take pipes along with Flashing & Top cap of the required size and colour complete with all necessary hardware complete. The roof shall be projected at-least 300 mm from the wall.

Stiffening ribs / subtle fluting for effective water shedding and special male / female ends with full return legs on side laps for purlin support and anti-capillary flute inside lap.

Both upper and lower sheets shall be separated through spacers and fastened through zinc /zinc-tin coated self-drilling screws. The fastener size shall be calculated as per the design or manufacturers recommendations.

Wall Insulation:

All voids of external and internal metalled walls shall have an under insulation of minimum 40 mm thick PUF with density 40 (+/- 2 kg/m3) and thermal conductivity 0.019-0.023 W/(m.K) at 10°C with proper supports etc. as approved.

Both the walls should be separated by spacers system made up of cold-formed steel bars and fastened through zinc /zinc-tin coated self-drilling screws.

The external wall of the Inverter room facing the transformer area shall be designed as a fire barrier meeting the appropriate Fire Resistance Level (FRL) and separation requirements in accordance with AS 2067 and the Fiji National Building Code (FNBC) (or the National Construction Code (NCC) of Australia).

Doors Frames:

Door frames shall be of the iron frame of mild steel sections. All doors shall be provided necessary fittings like hinges, handles, mortice locks, tower bolts, stopper, hydraulic door closer, etc. of CP brass complete fixed to Pre-Engineered structure including necessary filling up of gaps at junctions with required PVC/neoprene felt etc. including hinges / pivots and double action hydraulic floor spring/ hydraulic door closer of approved brand and manufacture, lock, handle and all necessary fittings as detailed in tender drawing or submitted by bidder in shop drawing and approved by Owner.

The door entrance shall include a Mild Steel single leaf door. The structural steel and sections shall conform to AS/NZS 3679.1 and AS/NZS 1594 (or AS/NZS 3678). The holdfasts shall be made from steel flats (50 mm wide and 5 mm thick). The fixtures, fastenings, and door latch are to be made with the same materials.

The Bidder can also propose uPVC extruded casement/sliding doors, with complete fittings, accessories, and panels conforming to the performance and testing requirements of AS 2047."

Windows Frame:

Aluminum black powder coated section, frame shall be of 92x31 mm, minimum 16G thick as per approved design. Tinted glass and aluminum grill shall be provided.

The Bidder can also propose **uPVC** extruded casement/ sliding windows with complete fitting and accessories. All windows have anti-theft metal grills.

Ventilators:

Aluminum black powder coated frame of minimum size 62x25 mm and 16G thick as per approved design. Ventilators/duct shall be provided with bird guard. Size of opening at the wall for ducts shall be as per PCU manufacture and min 18 gauge GI sheet. Ducts shall be supported with suitable means, as approved during detail engineering.

All accessible ventilators and windows of all buildings shall be provided with min. 4mm thick float glass, tinted for preventing solar radiations. Suitable sunshades made out of approved colour sheet will be provided to all external windows and door. The minimum projection for the sunshades will be 450 mm and 300mm wider than the width of the opening.

Rolling shutter:

Rolling shutter (Hand operated) shall be fabricated from 18 gauge steel and machine rolled with 75 mm rolling Shutter with effective bridge depth of 12 mm lath sections, interlocked with each other and ends locked with malleable cast iron clips and shall be designed to withstand a wind load without excessive deflection. Metal rolling shutters and rolling grills shall conform to the structural and wind-loading requirements of AS/NZS 4505."

Plinth Protection:

500 mm wide plinth protection minimum with 75 mm thick of cement concrete 1:3:6 (1cement : 3 coarse sand : 6 graded stone aggregate 20 mm nominal size) over 75 mm bed of dry brick ballast 40 mm nominal size well rammed and consolidated and grouted with fine sand including finishing the top smooth, shall be provided around the Pre-Engineered Building.

Floor Finish:

Flooring, including preparation of the surface, placement, and cleaning, shall be of cement concrete designed and constructed in accordance with AS 3600, incorporating a metallic dry-shake surface hardener (e.g., Ironite). The inverter room floor shall be at least 450 mm above the finished ground level. The building floor finish to be with 600 x 600 floor tiles with R11 slip rating.

Paint and Coating:

Metal sheet shall be colour coated with total coating thickness of 40 microns (nominal) dry film thickness (DFT) comprising of silicon modified polyester (SMP with silicon content of 30% to 50 %) paint or Super Durable Polyester (XRW) paint of 20 microns (nominal) on one side (exposed face) on 5 micron (nominal) primer coat and 10 microns (nominal) SMP or Super Durable Polyester paint over 5 micron (nominal) primer coat on other side (internal face). SMP and polyester paints system shall conform to Product type 4 as per AS/ANZ 2728.

Lighting:

The inverter room shall be provided with electric light to achieve an average illumination level of 150 Lux. However, room should be designed to utilize maximum natural light during the day.

Descriptions of PEB Structures:

Primary Members: Primary structural framing shall include the transverse rigid frames, columns, corner columns, end wall wind columns, beams, truss member, base pate.

Secondary Members: Secondary structural framing shall include the purlins, girts, eave struts, bracing, flange bracing, base angles, clips, flashings and other miscellaneous structural parts. Suitable wind bracings sag rods to be reckoned while designing the structure.

Sealant: Sealant used for cladding shall be butyl based, two parts polysulphide or equivalent approved, non-staining material and be flexible enough not to interface with fit of the sheets.

Closures: Solid or closed cell closures matching the profiles of the panel shall be installed along the eaves, rake and other locations

Flashing and Trim: Flashing and / or trim shall be furnished at the rake, corners, eaves, and framed openings and wherever necessary to provide weather tightness and finished appearance. Colour shall be matching with the colour of the wall. The material shall be 26 gauge thick conforming to the physical specifications of sheeting.

Gutters and Down Comers: Gutters shall be fabricated out of same metal sheet. Material shall be same as that of sheeting. Down comers shall be of galvanized steel pipes or PVC designed to ensure proper roof drainage system.

All steel materials supplied by the Agency shall be in a sound condition, of recent manufacture, free from defects, loose mill scale, slag intrusions, laminations, pitting, flaky, rust, etc. and be of full weight and thickness specified.

5.6.3 SPECIFICATION OF STORE ROOM:

One store (in addition to all other stores and PEB Invertor room) shall be constructed for storage of Mandatory Spares during O&M Period. The store shall have rolling shutter of proper width for entry with proper ramp & and shall have lock and key arrangement. The store shall be of min. 250 sq. mtrs. The Store can be developed as a Pre-Engineered Building with framed structure or an RCC building.

The height of store shall be minimum 5 meters and it shall be covered from all four sides. The store PEB size shall be minimum 250 square meter (width of approx. 7-10m. Refer Technical Specifications Part A for any additional requirements). The store shall have wide gate entry for crane movement and secured against theft etc. The roof and side walls of the store shall be made of permanently color coated galvalume profile sheets. The minimum BMT (Base material thickness) of roof and side wall sheets shall be 0.5mm. Gate provision shall be made on at least three sides of the shed with suitable ramps. The store shall be at least 500mm above NGL & minimum 1 meter height brick works above plinth level all around the store room. The roof sheet shall have a projection of 500 mm on all around.

The building shall be made of structural steel material as per relevant AS/NZS codes (such as AS 4100 and AS/NZS 3679.1). All RCC work shall be in line with AS 3600. Alternatively, the store shed may also be made with structural steel columns with a self-supporting roof truss system.

The store shed shall be designed in line with wind loads as per AS/NZS 1170.2. The store shed shall be designed as a permanent structure with a 25-year design life. The store shed flooring shall be made of 150mm thick RCC (reinforcement of N8 bars at

200mm c/c both ways, single layer, conforming to AS/NZS 4671) laid over 200mm thick well-graded and compacted boulders with sand. All structural members shall be painted with a minimum of two coats of synthetic enamel paint over one coat of primer, in accordance with the coating system guidelines of AS/NZS 2312.1. The design and drawing of the store shed shall be submitted for OWNER approval before the start of work.

5.7 GENERAL CIVIL WORKS

5.7.1 REINFORCED CONCRETE STRUCTURE, ALLIED WORKS AND FOUNDATION

- All RCC works shall be designed mix as per AS 3600. For structural concrete items, General Purpose Portland cement (Type GP) conforming to AS 3972 and Blended cement (Type GB) conforming to AS 3972 and AS/NZS 3582.1 shall be used for the superstructure. The type of cement for sub-structures shall be decided based on the approved geotechnical investigation report and special protection measures against chemically aggressive environments, specified at Cl.2.2 of Chapter C-1 of this specification.

- Coarse aggregate for concrete shall be crushed stones chemically inert, hard, strong, durable against weathering, of limited porosity, and free from deleterious materials. It shall be properly graded. It shall meet the requirements of AS 2758.1.

- Sand shall be hard, durable, clean, and free from adherent coatings of organic matter and clay balls or pellets. Sand, when used as a fine aggregate in concrete, shall conform to AS 2758.1. For plaster and masonry work, the fine aggregate shall conform to AS 2758.1 and the mortar requirements of AS 3700.

a) Reinforcement steel:

Non-coastal area	Coastal area
Reinforcement steel shall be high strength deformed steel bars of a minimum Grade 500 **(such as Grade 500N or 500E) and shall conform to** AS/NZS 4671**. Ductile detailing for seismic resilience in**	Reinforcement steel shall be high-strength deformed steel bars with corrosion inhibitors, Corrosion Resistant Steel (CRS) re-bars, Fusion Bonded Epoxy Coated (FBEC) re-bars conforming to AS 3921, or Zinc-Coated re-bars conforming to AS/NZS 4680. All

accordance with AS 3600 **(and/or** NZS 3101**) shall be adopted for the superstructure and substructure of all RCC buildings/structures.**	reinforcement shall be a minimum of Grade 500 (such as Grade 500N or 500E) and shall conform to AS/NZS 4671. Ductile detailing for seismic resilience in accordance with AS 3600 (and/or NZS 3101) shall be adopted for the superstructure and substructure of all RCC buildings/structures. Dense concrete around the reinforcement, the provision of thick covers, and the addition of corrosion protection with re-bars shall be provided to the RCC structures in strict accordance with the durability requirements of AS 3600

b) The following minimum grades of concrete for design mix and nominal mix shall be adopted for the type of structures noted against each unless not specified elsewhere.

Grade as per **AS 3600**	Non-coastal area	Coastal area
N30	-	All RCC structural elements above and below ground level, precast concrete, transformer foundation, Equipment foundation, cable trench, oil pit, Grade Slab, Paving, culverts, road and MMS Foundation.
N25 (in-situ concrete)	All RCC structural elements above and	-

N32 (Precast)	below ground level, precast concrete, MMS foundation, cable trench, oil pit, Grade Slab, Paving, culverts	
N25	Fencing work.	Fencing work, Base slab of drains. Plain Concrete Cement.
N25	Base slab of drains.	
N15/N20	Plain Concrete Cement.	

The bidder shall carry out the design mix of N32 and N25 grade concrete on priority. The design mix shall be approved from Owner before the start of work. The Contractor shall submit not less than 3 weeks before the commencement of Concrete works the preliminary trial design mixes and provide the following information to the Employer's Representative in respect of each grade of concrete.

i. Grade of concrete

ii. Title of particular trial mix.

iii. The grading of the aggregates.

iv. The ratio by weight of all the constituents of the concrete.

v. The expected compacting factor and slump.

vi. Full details of the proposed site quality control.

vii. Full details of the proposed laboratory for testing.

For each grade, a set of 3 cylinders shall be made from each consecutive batches. One cylinder shall be tested at an age of seven days and two at an age of 28 days. The cylinders shall be made, cured, stored, transported and tested in compression in accordance with AS 1012.3.1. The test shall be carried out in a laboratory which shall be approved by the Employer's Representative.

*The use of nominal mix for N20 grade (If applicable) may be accepted only in exceptional cases subject to approval of Owner's Engineer. The same shall be the adopted subject to approval from Owner for specific work.

c) In case Geotechnical investigations require any special kind of cement or higher grade of concrete, the same shall be provided. The foundation system shall be made which transfer loads safely to the soil for the module mounting structures, depending on soil conditions, geographical condition, regional wind speed, bearing capacity, slope stability etc. All foundation system and foundation depth shall be decided based on the approved geotechnical investigation report. No foundation allowed on back filled soil and the foundation depth to reach upto natural ground level (NGL).

d) All loads shall be considered in line with the AS/NZS 1170 series. Seismic loads for design shall be in accordance with AS 1170.4 (or NZS 1170.5) and relevant standards.

e) The bending, fixing, and detailing of concrete reinforcement must comply with the provisions of AS 3600 and AS/NZS 4671. Accepted industry-standard detailing practices (such as the SRIA reinforcement detailing guidelines) shall be followed for all reinforcement detailing.

f) A minimum 75 mm thick PCC (Plain Cement Concrete) blinding layer shall be provided below the RCC wherever an RCC structure is laid over the ground. Proper and sufficient formwork/shuttering shall be provided for the required period as per AS 3610 and AS 3600.

g) The minimum Testing Frequency for sampling concrete shall be in accordance with the frequency specified in AS 1012/ AS 1379 and shall be distributed evenly over the number of truckloads being delivered, namely;

i.	1 Truck	one sample
ii.	2-5 trucks	two samples
iii.	6-10 trucks	four samples

iv. 11-12 trucks five samples

Each sample (1 truck ~ 5m^3) to consist of 3 cylinders, which are to be tested one on 7 days and two on 28 days. The testing will be carried out at an independent laboratory which is IANZ accredited.

Slump Test to be carried out for every truck delivered to site in Accordance with Australian Standard AS 1012.3.1 and as directed by the Engineer. These tests may be carried out by suitably trained manufacture's personnel, and the manufacture shall provide all equipment's and pay all associated cost.

The consistency of the concrete shall be such as to produce a slump under test within the range shown for the specific grade of concrete.

Consistency of the concrete shall not be adjusted by the further addition of water to the mix.

Masonry Work

a) Brickworks and concrete blocks shall be of an approved quality conforming to AS/NZS 4455.1. Concrete blocks and bricks shall have a minimum characteristic compressive strength of 7.5 MPa. Stone masonry work with hard stone in building works, foundations, plinths, and drains shall be Coursed Rubble or Random Rubble masonry work with stone of good quality and durability. The design and construction of all masonry (including stone) shall be in accordance with AS 3700. The masonry surface shall be plastered with a minimum 18mm plaster in the case of CMCS walls.

b) The cement mortar for all kinds of masonry work shall be in the ratio of 1 cement to 6 sand by volume/weight (or an equivalent M3/M4 mortar class) and shall conform to the requirements of AS 3700.

c) Bricks/blocks required for masonry work shall be properly prepared and moistened to control suction in accordance with masonry best practices. Bricks shall be laid in English bond style. Green masonry work shall be protected from rain. All masonry work shall be cured and kept moist on all faces for a period of seven days.

d) Bricks with a lower compressive strength of 5.0 MPa and 3.5 MPa may be permitted for use in non-load-bearing structures, provided no difficulty arises in laying uniform courses and subject to the prior approval of the OWNER. Dimensional

tolerances shall comply with the dimensional deviation categories of AS/NZS 4455.1. Dimensional testing shall be carried out as per AS/NZS 4456.

e) The external wall for the building shall be 230 mm thick, and internal walls 230 mm or 115 mm thick as per requirements. The external wall of the CMCS facing the transformer area shall be constructed as a fire barrier in accordance with AS 2067 and the Fiji National Building Code (FNBC).

f) The use of **Concrete Masonry Units (CMU)"** or **"standard concrete blocks."** for masonry shall be subject to the approval of the OWNER.

g) A suitable damp-proof course (DPC) conforming to AS/NZS 2904 shall be provided. Where a concrete/mortar DPC is adopted, the proportion of cement, sand, and aggregate shall be 1:2:4 using 6 mm down stone chips with a waterproofing admixture. The thickness of the damp-proof course shall be a minimum of 40 mm.

Plastering

All external surfaces shall have 18 mm cement plaster in two coats: an underlayer of 12 mm thick cement plaster (1:5 mix ratio) and finished with a top layer of 6 mm thick cement plaster (1:6 mix ratio). A white cement primer shall be used as per the manufacturer's recommendations.

At least one coat of plaster shall be applied to interior walls by hand or mechanically, to a total thickness of 12 mm using a 1:6 mix (1 part cement to 6 parts sand). The sand used for plastering shall conform to AS 2758.1, and the application shall conform to accepted industry practices and the Fiji National Building Code (FNBC). A modern, high-quality acrylic/emulsion paint system on a smooth surface shall be applied with a minimum 2 mm thick skimming/gypsum plaster finish for the control room in accordance with AS/NZS 2589.

Water Supply

GI pipes of Medium quality conforming to AS 1074, or WaterMark-certified CPVC/PVC pipes conforming to the relevant AS/NZS standards (such as AS/NZS 1477), shall be used for all potable hot and cold-water distribution supply and plumbing works in accordance with AS/NZS 3500.1.

A polyethylene/PVC water storage tank conforming to AS/NZS 4766 shall be provided over the roof of the CMCS with adequate capacity for 10 persons and 24-hour requirements, complete with all fittings including a float valve, stopcock, etc. The capacity of the tank shall be a minimum of 5000 Liters with automatic pressure pump.

The tank(s) shall be suitably covered/thermally insulated to prevent the overheating of water due to direct sunlight.

Grouting

Cement mortar (1:2) grout with non-shrink additives shall be used for grouting below base plate of a column. The grout shall be high strength grout having a minimum characteristic compressive strength of min 30 N/mm2 at 28 days.

Structural Steel

Structural steel design shall be carried out as per AS 4100 (or NZS 3404) and AS/NZS 4600. Structural steel shall conform to AS/NZS 3679.1, AS/NZS 3678, or AS/NZS 1594 (or equivalent). Pipes and hollow steel sections for structural use shall conform to the medium/high grades of AS/NZS 1163, and chequered plates (floorplates) shall conform to AS/NZS 3678.

Structural Steel/Steel Sheet Painting

All non-hot dip galvanised structural steel (excluding Module Mounting & SCB structures) / Outdoor metal containers / Enclosures / Rolling shutter items shall be provided with paint designed for a minimum maintenance-free life of fifteen (15) years (high durability) as per AS/NZS 2312.1 and AS 4100 (or NZS 3404) or equivalent for its corrosion category. For the finishing coat, a suitable colour pigment shall be added. All paints, including the primer, shall be of a reputed brand/manufacturer and as approved by the Owner's Engineer. The method of application shall be as per the recommendations of the manufacturer. For the corrosive category, refer to the appendix of site-specific data.

Transformer Yard and Metering Yard Civil Works

a) Transformer and equipment's foundations shall be founded on piles/isolated spread footings depending on the final geotechnical investigation report. Metering yard equipment's structures shall be designed as per AS/NZS 4600 and AS 4100 (or NZS 3404).
b) Transformer foundations shall have its own pit which would cover the area of the transformer and cooler banks, so as to collect any spillage of oil or oil drainage in case of emergency. The oil pit shall be filled with granite stones of 40 mm size uniformly graded.

c) The bidder can propose soak pit under Transformer or Burnt oil pit at a distance connected to transformer soak pit depending upon oil quantity in Transformers. It shall be sized to accommodate the oil volume of the transformer connected to it, without backflow. The Gravel-filled level under transformer shall be in accordance with FGL outside pit and transformer bottom level.

d) The power transformer bund to be connected to oil separator pit to comply with AS/NZS 2067 which requires capacity for 110% of the largest oil volume, gravity drainage, and an oil-water separation mechanism. The layout must prevent environmental spills and contain fire risks.

e) The area around the transformer and equipment's shall be covered with gravel and galvanized chain link fence of height min 1.8 m with fence posts and gates shall be provided. The portion of the fence covering towards rail track shall be made of a removable type for movement of the transformer during erection /removal. In addition, a small gate, 1.2 m wide shall be provided for an entry. The transformer yard fencing work shall conform to "EFL (Energy Fiji Limited) requirements.

f) Transformer track rails shall conform to AS 1085.1. The requirement of a fire barrier wall between transformers shall be as per the local Energy Fiji Limited (EFL) regulations and the fire separation recommendations of AS 2067

PIPE /CABLE RACKS & TRENCHES

a) The conventional methods of cable laying and installation shall conform to AS/NZS 3000 (and AS 2067 for high voltage cables) for laying direct in ground, drawing in ducts, laying on racks in air, laying on racks inside a cable tunnel, and laying along buildings or structures, etc. Any specific trenching and installation guidelines mandated by the local utility, Energy Fiji Limited (EFL), shall also be strictly observed.

b) Outdoor RCC Cable Trenches: RCC outdoor cable trenches in switchyard area shall be provided with pre-cast RCC removable covers with lifting arrangement. The top of outdoor trenches shall be kept at least 100 mm above the gravel level so that rainwater does not enter the trench.

c) Indoor RCC Cable Trenches: RCC indoor cable trenches shall be provided with **50X50X4** mm angles grouted on the top edge of the trench wall for holding minimum 6 mm thick mild steel checkered plate covers with lifting arrangement.

d) RCC cable trenches shall be constructed with wall thickness minimum 100 mm.

e) Trench Drainage: The trench bed shall have a slope of approx. 1/500 along the run & 1/250 perpendicular to the run. Incase straight length exceeds 30 m, suitable expansion joint shall be provided at appropriate distances. The expansion joint shall run through vertical wall and base of the trench. All expansion joints shall be provided with approved quality PVC water stops. Suitable drainage at the lowest point of the trench shall be provided.

5.7.2 PLANT DRAINAGE SYSTEM

a) All Drains within a plot are in Bidder's Scope. Lining of drains shall be as per provisions of Bidding Documents and applicable Code provisions.

b) Surface drainage system shall be designed considering 'Minimum of 100mm/hr with factor of safety 1.5'. The minimum value of the surface runoff coefficient shall be considered as 0.6 in the design of the drainage system. The drainage system shall be designed as per specifications and prevailing industry practices.

c) The drainage scheme shall be designed considering the catchment areas contributing to the existing drains, solar plant gradients and solar PV array layout. As per plant drainage requirement, a network of open drains shall be designed & provided to carry surface runoff. The drains shall be trapezoidal, rectangular section made of earthen type lining (Compacted Earth Lining) and hard surface lining (stone masonry/pitched, Boulder, Precast cement concrete/stone slab, *in-situ* cement lime/concrete lining, soil cement lining, etc.)

d) Bidders can also propose suitable detention pond, recharge dugwells, recharge pits, recharge trenches, and recharge soakways for quick disposal of storm water in the vicinity of the solar block/plot.

e) Bidder shall also ensure that drainage from his plot does not encroach/flood into the adjacent property and adjacent solar plots (if any). Bidder shall try to maintain existing natural drain and shall remodel the natural drains in case of any disturbance made. The same shall be as per the technical/design requirements without affecting the drainage pattern. The bidder plot drainage scheme shall include to drain out the drainage of the allotted plot and shall include contributing catchment area consisting of adjoining plots and nearby catchment area.

f) Provision of culverts and their design to be submitted separately. The road on the culvert portions of the drains shall be a concrete road.

g) All Buildings shall be provided with plinth protection all around, sloped towards side drains. Plinth Protection shall be 75mm thick PCC laid over a well-compacted 75 mm granular sub-base or crushed aggregate base. Building peripheral drains

shall be stone masonry/brick masonry/concrete works. These side drains shall be connected to area drains by either open drains or a combination of open drains and underground pipes.

h) Grade level shall be fixed with due reference to the highest high flood level of the receiving body of water. Laying of Hume pipe shall be in line with AS/NZS 3725 (Design for installation of buried concrete pipes)

i) Recommended Side Slopes for lined and unlined drains, other than RCC drains and Brick wall drains

Sl	Type of Soil	Side Slopes (Horizontal: Vertical)
1.	Very light loose sand to average sandy soil	2: 1 to 3: 1
2.	Sandy loam, Ordinary soil	1.5 : 1 to 2 : I (in cutting) 2 : I (in embankment)
3.	Sandy gravel/murum	1.5 : 1 (in cutting) l.S : I to 2 : I (in embankment)
4.	**"expansive clay soil"** or **"highly reactive clay."**	1.5 : 1 to 2.5 : I (in cutting) 2 : I to 3.5 : I (in embankment)
5.	Clayey soils	1.5 : I to 2 : I (in cutting) 1.5 : 1 to 2.5 : I (in embankment)
6.	Rock	0.25 : 1 to 0.5 : 1

i) A. Limiting velocity in **unlined drains**:

Very light, loose and to average sandy soil	**0.60 m/sec.**

Ordinary soil, Sandy loam, "expansive clay soil" **or** "highly reactive clay." **& similar soil**	0.90 m/sec.
Engineered fill, lateritic gravel, or crushed rock, hard soil	1.1 m/sec.
Gravel and disintegrated rock	1.5 m/sec.

A. Limiting Velocities in Different Types of **Lining in drains**:

Stone-pitched lining	**1.5 m/s**
Burnt clay tile or brick lining	1.8 m/s
Cement concrete lining	**2.7 m/s**

All above parameters may be suitably adjusted based on inputs being made available by Owner (Owner) for reference purpose. Also, any specific reference mentioned for Drain design in any AS/NZS Code would also be acceptable subject to approval of overall design during detailed Engineering stage.

All project drains would connect to the main drains of Park as per detailed layout to be prepared during detailed Engg. stage.

5.7.3 ELECTRIFICATION OF BUILDING

Electrification of all buildings shall be carried out in strict accordance with AS/NZS 3000 (Electrical installations) and any other relevant AS/NZS electrical safety standards, as well as the service rules of the local utility, Energy Fiji Limited (EFL).

5.7.4 APPROACH ROADS

The roads to the Solar Power Plant shall originate from the main approach road/ Highway and connect to all inverter rooms, CMCS building, Metering yard/Switchyard and Gates.

5.8 SUBMISSIONS

The following documents shall be submitted by the Bidder for approval of the Employer, prior to commencement of fabrication and erection / construction. This list is not exhaustive but indicative only:

1. G. A. drawing showing co-ordinates of various Gantry structures and facilities.
2. Drawing showing underground facilities with co-ordinates of all facilities such as Tower/LM foundations, equipment foundations, Transformer foundations R.C.C cable trenches, cable ducts, drains, sump pits, culverts, other foundations etc.
3. Proposed erection / construction scheme for various structural and civil works envisaged as per design requirement.
4. Foundation design & drawing for equipment supports, their control cubicles, bus post supports and bay marshalling kiosks.
5. Details of RCC cable trenches and duct banks with necessary precast RCC removable covers with lifting facility, sump pits, cable tray supports etc.
6. Foundation design & drawing for Solar Power Transformer as required including associated rail tracks, oil soak pits, oil separation pits, firewall etc.
7. Design & drawing of roads and drains including road/drain/trench crossings.
8. Site preparation, soil sterilization / antiweed treatment including gravel filling, but excluding major leveling as required.
9. Fencing along with gate for the switchyard extension area wherever required.
10. Modification required in the existing Switchyard control room building for installation of Control & protection panels, as applicable.
11. Structural steel fabrication drawings and Reinforcement bar bending schedules for reference.
12. Electronic soft copy of all the approved drawings/calculations in Cat-II / Cat-I.

5.9 DESIGN CRITERIA SWITCHYARD STRUCTURES

General

All switchyard structures Gantry Towers & Beams, Lightning mast, Equipments supporting structures, Transformer foundations including oil pit, rail track, fire wall, cable trenches, Roads, Culvert, Drains, sewers, water supply, fencing with gates, gravel filling & antiweed treatment, disposal of soil, leveling/dressing of switchyard extension area etc. and other related works all complete, as applicable are covered in the specification.

Structures shall be designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, piping loads (static and dynamic), wind

loads, seismic loads and temperature loads. In addition, loads and forces developed due to differential settlement shall also be considered.

Loading

Dead Loads

Permanent (dead) loads shall include the weight of the structure complete with finishes, fixtures, and partitions, and shall be taken as per AS/NZS 1170.1.

Imposed Loads

Imposed loads in different areas shall include live, erection, operation and maintenance loads. Equipment loads (which constitute all loads of equipment to be supported on the building frame) are not included in the imposed loads furnished below and shall be considered in addition to imposed loads.

For consideration of imposed (live) loads on structures, AS/NZS 1170.1 (Structural design actions - Permanent, imposed and other actions) shall be followed. The following minimum imposed loads as indicated for some of the important areas shall, however, be considered for the design. If the actual expected load is more than the specified minimum load, then the actual load is to be considered."

If actual expected load is more than the specified minimum load, then actual load is to be considered.

Equipment loads

Loads of all equipment like Electrical control and relay panels, cable load, Pipe load (static and dynamic), Tanks, etc. shall be considered over and above the imposed loads. Cable and piping loads not less than 5 kN/sq.m hanging from the underside, shall also be considered additionally for floors where these loads are expected.

Crane Loads

For crane loads, an impact factor of 25% and lateral crane surge of 10% (of lifted weight + trolley weight) shall be considered in the analysis of the frame according to the provisions of AS/NZS 1170.1 and AS 1418.1. The longitudinal crane surge shall be 5% of the static wheel load.

Monorail loads shall be considered in the analysis of the frame according to the provisions of AS/NZS 1170.1 (latest revision) and AS 1418.1.

Wind Load

a) Switchyard gantries, towers, equipment supporting structures, and lightning masts shall be designed as per AS 3995 (for lattice towers and masts) and AS 4100 (for steel structures). The wind load calculations shall be made as per AS/NZS 1170.2, considering the regional wind speed, wind direction multipliers, and terrain category applicable to the site.

b) All other structures covered under the present package shall be designed as per AS 3600 (for concrete structures) and AS 4100 (or NZS 3404) (for steel structures). The wind load calculations shall be made as per AS/NZS 1170.2.

Seismic Load

Seismic loads and earthquake-resistant design for all project structures—including buildings, equipment supporting structures, switchyard gantries, and foundations—shall be calculated and applied in strict accordance with AS 1170.4 or NZS 1170.5, and the seismic provisions of the Fiji National Building Code (FNBC).

The site-specific hazard factor (Z), structural importance level, and site sub-soil class shall be derived from the approved geotechnical investigation report. All structural elements must incorporate appropriate ductile detailing to satisfy the ductility demands of the calculated seismic actions. This detailing shall comply with the relevant material design standards, specifically AS 3600 (or NZS 3101) for reinforced concrete structures, and AS 4100 (or NZS 3404) for structural steel elements.

Design Parameters for Gantry Towers & Beams, Lightning Mast and Equipment Supporting Structures (as applicable)

a) Gantry structures, which consist of open web towers connected by girders, shall be made of structural steel conforming to AS/NZS 3679.1 or AS/NZS 3678 (minimum Grade 300) and duly hot-dip galvanized conforming to AS/NZS 4680. All joints shall be bolted connections.

b) The analysis of towers and gantries shall be carried out with a combined model of the critical configuration of towers and gantries using established structural analysis software (e.g., STAAD.Pro).

c) All bolts for connections shall be 16mm diameter, conforming to the mechanical properties of AS/NZS 4291.1 and the dimensional requirements of AS/NZS 1111.1 (or AS/NZS 1252.1 for high-strength friction grip bolts, if applicable). Nuts

shall conform to AS/NZS 1112.3. Foundation/anchor bolts shall conform to Property Class 4.6 as specified in AS/NZS 4291.1 and AS/NZS 1111.1.

d) Butt splices shall be used for splicing the main members, and the splice shall be located away from the node point in accordance with the detailing provisions of AS 3995.

e) AS 3995 (Design of steel lattice towers and masts) shall be followed for the design of structures. The height and type of towers shall be established based on electrical requirements. A provision of ± 30 degree angle of deviation of the line in the horizontal plane and ± 20 degree deviation in the vertical plane shall be considered, and the resulting worst combination of forces shall be considered for the design.

Loads and Loading Conditions

Switchyard structures shall be designed for the worst combination following loads:

1) Dead loads (load of wires/conductors, insulator, electrical equipment and structural members),
2) live loads,
3) Wind load on bus bars, shield wires, insulator strings, electrical equipment, structural members etc as per "AS/NZS 1170.2" and "AS 3995".,
4) seismic loads,
5) loads due to deviation of conductor (gantries shall be checked for ± 30 deg. deviation in horizontal plane and ± 20 degree deviation in vertical plane),
6) loads due to unbalanced tension in conductor/wire,
7) Torsional load due to unbalanced vertical and horizontal forces,
8) Erection loads,
9) Short circuit forces including snap in case of bundled conductors, etc.

Note:

The occurrence of earthquake and maximum wind pressure is unlikely to take place at the same time. The structure shall be designed for either of the two. However, temperature stresses can be ignored, as these towers are freestanding structure in open space.

Short circuit force and wind shall be considered to act simultaneously for the purpose of structure design.

Direction of wind shall be assumed such as to produce maximum stresses in any member for the combination of wind load with conductor tensions. The wind acting perpendicular and parallel to bus conductor and shield wire shall be considered separately.

The conductor tension shall be assumed as acting on only one side of the gantry for the analysis and design of switchyard gantries for both normal and short circuit condition.

Factor of safety:

The factor of safety for the design of members for switchyard structures shall be considered as 2.0 for normal condition and 1.5 for short circuit condition.

Design consideration for Equipment support:

The supporting structures for B.P.I., LA, CVT, and Isolator equipment shall be comprised of galvanized Circular Hollow Sections (CHS) of minimum Grade C250 conforming to AS/NZS 1163 and shall be designed as per AS 4100.

The minimum diameter of the pipe-type support for structures shall be 200 NB (Nominal Bore). For higher voltage levels, the relevant standards shall be followed.

The supporting structure for CT equipment shall be comprised of lattice structural steel conforming to AS/NZS 3679.1 and shall be designed as per AS 3995.

A common raft foundation shall be provided for each pole of the isolator.

Special design consideration for Lightning Mast (as applicable):

Diagonal wind condition shall be considered for Lightning Mast. Diagonal wind shall be taken as 1.2 times the wind calculated on longitudinal/transverse side. Lightning mast shall be provided with minimum two nos. of platforms as per requirement and an internal ladder for climbing purpose shall be provided up to the platforms. Top of platform shall have grating, railing and two guard plates. The minimum width of platform shall be 900mm.

Live load of 300kg/m2 above platforms shall be considered for design of Lightning Mast.

The fabrication and erection of the switchyard works shall be carried out generally in accordance with AS 3995 (for lattice structures) and AS 4100 or NZS 3404 (for general

steel structures). All materials shall be completely shop-fabricated and hot-dip galvanized in accordance with AS/NZS 4680.

Minimum Thickness of Members & Galvanization

All steel work used in construction of switchyard structures such as Towers & Beams, Lightning mast and equipment supporting structures including nuts, bolts and washers shall be galvanized.

Minimum section thickness shall not be less than 4 mm. Weight of zinc coating shall be at least 0.610 kg/m2 and foundation bolts shall have heavier zinc coating of at least 0.80 kg/m2.

Design consideration for Foundation

The factor of safety (F.O.S) for foundation shall be 10% more than factor of safety for supporting structure i.e. 2.2 for normal condition and 1.65 for short-circuit condition

Tie-Transformer foundations

Following are applicable for tie transformers. For higher voltage level transformers, relevant standards shall be followed for civil design.

Foundations of transformer shall be designed for seismic and wind loads. Block foundations shall be provided for the main transformer block.

Oil soak pits shall be provided around the transformers to prevent spillage of oil from transformers onto the ground. The oil soak pit shall be filled with gravel of size 40mm. The volume of the soak pit shall be sufficient to store complete oil of the transformer along with 10 minutes of fire water considering only 40% of the volume as available voids between gravel filling. However, in case a separate oil collection tank is provided for the transformer, the minimum volume of oil soak pit around transformer shall be provided as one-third of the oil volume of transformer. The oil collection tank, in such cases, shall be designed for an effective capacity of complete oil of the transformer along with 10 minutes of fire water. The oil soak pit shall also be provided with a sump at the corner to allow drainage of water/oil from the soak pit.

Arrangement for moving the transformer in place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer foundations.

Firewall shall also be provided between the transformers wherever required.

300 mm thick PCC M20 encasement all around the Pylon supports for fire fighting system shall be carried out up to top of gravel filling. However, the supply and erection of Pylon supports with anchor fasteners for HVW// N_2 spray system are under scope of EPC contractor. Coarse aggregate filling inside the transformer oil soak pit shall be carried out only after construction/erection of Pylon supports and PCC encasement.

GRAVEL FILLING (as applicable)

Gravel filling shall be provided in the switchyard extension area inside the fence as indicated in the tender drawing with broken stone filling which shall consist of two layers. The first layer shall be 75mm thick base course of 20mm of normal size and second layer shall be 75mm thick surface course of 40mm nominal size. Each layer shall be compacted by using half ton roller with 4-5 passes and suitable water sprinkling. Before laying the gravel/stone fill, the top layer of the soil shall be treated for anti-weed considering the type of weeds found in the vicinity. The anti-weed - soil sterilization details such as manufacturer's name, their specification, test certificate, etc. shall be furnished for Owner's approval. Any modification if required in the proposed anti-weed treatment chemical shall have to be done by the contractor at no extra cost to the Owner.

The Material & Physical Specifications for the Antiweed mat:

- Fabric Type: High-tensile Woven Polypropylene (PP) geotextile (such as Groundtex Woven Geotextile or equivalent civil-grade stabilization membrane).
- Mass/Grammage (GSM): Minimum 130 GSM to 200 GSM to handle separation and load distribution under vehicular traffic.
- Tensile Strength: ≥ 20 kN/m (longitudinal and transverse) conforming to EN ISO 10319.
- CBR Puncture Resistance: ≥ 2.0 kN conforming to EN ISO 12236 to prevent stone penetration from heavy truck tires.
- UV Stabilization: Treated with 3% to 5% UV inhibitors for exposed perimeter longevity, though the main yard should be ballasted.

The contractor shall be required to furnish a performance guarantee of three years for the anti-weed treatment. This guarantee shall be commenced from the date of completion of work or date of handing over, whichever is later.

CABLE TRENCHES (as applicable)

Cable trenches shall be provided for routing of cables as required and shall be of adequate size. The trenches located within switchyard shall project at least 300 mm above the finished formation level so that no storm water shall enter into the trench. The bottom of trench shall be provided with a longitudinal slope of 1:500. The downstream end of cable trenches shall be connected to sump pits.Lifting hooks shall be provided in the precast covers. Trenches shall be given a slope of 1:250 in the direction perpendicular to the run of the trenches. Angle of size 50x50x6 mm (minimum) with lugs shall be provided in the edges of RCC cable trenches and any other place where breakage of corners of concrete is expected.

SWITCHYARD DRAINS (as applicable)

Open RCC storm water drains shall be provided on both sides of the road and inside switchyard area for proper drainage. All drains shall be designed for maximum runoff velocity of 1.8 m/sec. The thickness of side wall and bottom slab of RCC drains shall be minimum 100 mm. RCC box/pipe culvert shall be provided for road, rail and trench crossings.

CHAIN LINK FENCING (as applicable)

Refer tender drawing. Title: Details of chain-link fencing for yard and common fencing.

CORROSION PROTECTION MEASURES

All structural steel and RCC members/ structures shall have to be provided with corrosion protection treatment unless specified otherwise.

Structural Steel

Corrosion Protection

i) General

a) All Painting shall be done as per approved painting scheme of the Vendors/ Manufacturers, which shall be submitted by the Bidder and as approved by the Employer. Painting scheme shall also include Item codification/ Description of all Coats of Paints for manufacturer's, from whom the Paint is intended to be procured.

b) All steel structures (except those embedded in concrete), unless specified otherwise, shall be provided with a protective paint system designed for a minimum maintenance-free life of ten (10) to twenty (20) years in accordance

with the durability guidelines of AS/NZS 2312.1.All Paints shall be of high build constitution.

ii) Painting of Steel Surfaces embedded in Concrete

For the portion of Steel surfaces embedded in Concrete, the surface shall be prepared by Manual Cleaning and provided with Primer Coat of Chlorinated Rubber based Zinc Phosphate Primer of Minimum 50 Micron Dry Film Thickness (DFT).

iii) Painting of Steel Surface

a) All Steel surfaces shall be provided with self-curing Inorganic Zinc Silicate Primer Coat (Solid by Volume Minimum 60%) of Minimum 75 Micron Dry Film Thickness (DFT) applied over blast cleaned surface to near white metal conforming to Sa 2 ½ finish of Swedish standard SIS –05-5900.

b) Primer Coat shall be followed with the application of Intermediate Coat of Polyamide Cured pigmented Titanium Dioxide (TiO2) or Micaceous Iron Oxide (MIO) Epoxy based Paint (Solid by Volume Minimum 60%) of Minimum 75 Micron DFT. This coat shall be applied in Shop after an interval of Minimum overnight (from the application of Primer Coat).

c) Intermediate Coat shall be followed with the application of Finish Coat of Polyamide Cured colour pigmented Epoxy based paint (Solid by Volume Minimum 60%) of Minimum 75 Micron DFT. This Coat shall be applied after an interval of Minimum overnight and maximum indefinite (from the application of Intermediate Coat) either before Erection by Airless spray technique or after Erection by brush and / or spray. Colour and shade of the Coat shall be as approved by the Employer. The Finish Coat thickness of 75 Micron can be built up either in Single application at Shop or in two applications one at Shop and the other at Site.

d) Finish Coat shall be followed with the application of Final Finish Coat of Polyurethane based colour pigmented Paint (Solid by Volume Minimum 40%) of Minimum 30 Micron DFT. This Coat shall be applied within Seven (7) days (from the completion of Finish Coat) after Erection by brush and/ or spray. Colour and shade of the Coat shall be as approved by the Employer.

iv) Touch-up Painting on damaged areas

a) For Coatings damaged up to metal surface

Surface preparation shall be carried out by Manual Cleaning. Minimum 6 inches adjoining area with existing Coating shall be roughened by Wire brushing, emery paper rubbing etc., for best adhesion of patch Primer.

Primer Coat of self-priming Epoxy Touch-up Primer applied by brush immediately after the surface preparation. (Minimum DFT 100 Microns).

Over this Primer Coat, Intermediate Coat, Finish Coat and Final Finish Coat shall be applied as covered above by brush with Intermediate Coat applied within maximum seven (7) days of application of touch up Primer.

b) For Coatings damaged up to Intermediate Coatings (i.e. where Primer Coat is intact).

Damaged area including Minimum 6 inches adjoining area with existing Coating should be roughened by wire brushing emery paper rubbing etc., for best adhesion of patch Primer without damaging the Primer Coat.

Touch-up Primer, Intermediate, Finish and Final Finish Coats shall be applied as specified above for Coatings damaged up to metal surface.

v) Painting of Welded areas / painting of areas exposed after removal of temporary supports/ Touch-up Painting on damaged areas of Employer's Structures, where inter-connection, Welding/ modification etc. has been carried out by the Bidder.

a) Clean the surface to remove flux spatters and loose rust, loose Coatings in the adjoining areas of Weld seams by wire brush and emery paper.

b) Painting procedure to be followed as mentioned above for Touch-up Painting on damaged areas.

vi) Coating **for Mild Steel parts in contact with Water**

All mild steel parts coming into contact with water or water vapour shall be hot-dip galvanized. The minimum coating mass of zinc shall be 610 g/m^2 for galvanized structures and shall comply with AS/NZS 4680. Galvanizing shall be checked and tested in accordance with the provisions of AS/NZS 4680.

OR

All mild steel parts coming into contact with water or water vapour shall be protected with a sealed thermal sprayed zinc coating, designed for a very long (20 or more years) maintenance interval in accordance with AS/NZS 2312.2.

vii) Gratings

All gratings shall be abrasive blast-cleaned to a Class 2.5 finish in accordance with **AS 1627.4**, and shall be hot-dip galvanized with a minimum coating mass of 610 g/m^2 in accordance with **AS/NZS 4680**.

viii) Hand Railings and Ladders

All handrails and ladders shall be galvanised at the rate of 610 gms / Sq.M as per AS/NZS 4680

RCC Members (Superstructure)

The following preventive measures are required to be adopted by the bidder as minimum requirement.

i) For Indoor RCC Members

a) Dense and durable concrete is to be used. Minimum grade of concrete shall be N25.

b) Water/ cement ratio shall generally be restricted to 0.5. Plasticizer, if required may be used.

ii) For Outdoor (or exposed) RCC Members

a) Dense and durable concrete is to be used. Minimum grade of concrete shall be N25.

b) Water/ cement ratio shall generally be restricted to 0.5. Plasticizer, if required may be used.

RCC Members (Underground Sub-Soil Condition)

The type of corrosion protection measures for concrete reinforcement steel and structural steel for underground structures/ facilities shall be as specified elsewhere in specification.

Protective measures shall be according to Geotechnical investigation and foundation system. In addition, Water/ cement ratio shall generally be restricted to 0.45.

MISCELLANEOUS SPECIFICATIONS

- A two-part elastomeric sealant (such as polysulphide or polyurethane) conforming to ISO 11600 shall be used for the sealing of joints.
- Preformed compressible joint filler board (such as bitumen-impregnated fibre board) shall be used as joint filler.
- Monorails, monorail girders, and fixtures shall be provided wherever required to facilitate the erection/maintenance of equipment.
- The height of the reinforced concrete (RCC) fire protection wall between transformers shall be as per system requirements and local utility guidelines.

- Mild Steel (MS) angles of a minimum size of 50 x 50 x 6 mm with 8mm dia - 150mm long MS lugs @ 150mm c/c shall be provided for edge protection around all cutouts/openings in floor slabs/walls, edges of drains supporting grating/pre-cast covers, edges of cable trenches supporting pre-cast covers or chequered plates, edges of manholes supporting covers, around the periphery of all removable pre-cast covers, and any other place where the breakage of concrete corners is expected.

- Grouting of all pockets, blockouts, sleeves, openings around embedments, inserts, bolts, etc., and underpinning below the base/sole plate shall be done with a non-shrink flowable grout. The strength of the grout shall be one grade higher than the base concrete. However, the minimum compressive strength of the grout shall be 30 MPa.

- In areas subjected to vehicular loads, precast reinforced concrete covers of suitable thickness, without perforations and designed for the expected vehicular loading in accordance with AS/NZS 1170.1, shall be provided.

- Anti-termite chemical treatment shall be applied to all vulnerable areas susceptible to termites, including column pits, wall trenches, building foundations, and fill below floors, as per AS 3660.1.

- Wherever possible, a minimum 900 mm high handrailing shall be provided around all floor/roof openings, projections/balconies, platforms, walkways, etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) conforming to AS/NZS 1163 and shall be hot-dip galvanized as per AS/NZS 4680. All rungs and ladders shall also be galvanized. The minimum coating mass of galvanizing shall be 610 g/m^2.

- Duct banks consisting of PVC conduits for cables shall be provided with a proper sealing arrangement utilizing a fire-retardant sealing compound.

- Unless otherwise specified, all sand filling shall be compacted to a minimum of 80% Density Index, and backfilled earth shall be compacted to a minimum of 90% Unless otherwise specified, all sand filling shall be compacted to a minimum of 80% Density Index, and backfilled earth shall be compacted to a minimum of 90% Maximum Dry Density (MDD) at Optimum Moisture Content (OMC) using standard compaction effort in accordance with AS 3798

- However, the sub-grade for roads shall be compacted to a minimum of 95% Maximum Dry Density (MDD) at Optimum Moisture Content (OMC) using standard compaction effort.

- Non-shrink flowable grout shall be used for underpinning work below base plates. The nominal thickness of the grout shall be 50 mm. A non-shrink cum plasticizer admixture shall be added to the grout. The crushing strength of the grout shall generally be one grade higher than that of the base concrete, with a minimum compressive strength of 30 MPa.

- Suitable expansion joints shall be provided in the longitudinal direction wherever necessary, with the provision of twin columns.

- The design, construction, and joints of all structures shall be as per the relevant AS/NZS codes and the Fiji National Building Code (FNBC) unless specified otherwise.

- All foundation embedments, inserts, and blockouts required for mounting equipment and supporting any other facilities like pipes, etc., shall be provided.

- All cable trenches shall be provided with suitable insert plates for fixing the support angles of cable trays.

- An earthing mat shall be provided around buildings and structures as per the specifications and approved drawings.

- A detailed scheme for dewatering shall be prepared before the start of deep excavation work. AS 3798 and local Fiji environmental guidelines shall be followed as general guidance for dewatering.

- Heavy-duty steel rail (minimum 50 kg/m conforming to AS 1085.1) shall be used for rail tracks required for the movement of Transformers.

REQUIREMENTS FOR CONCRETE

Structural concrete shall be of design mix complying with the relevant provisions of AS 3600 and AS 1379 or any International Code of Practice as approved by the Employer. All concreting shall be carried out using centralized batching plant, transit mixers and concrete pumps. Numbers and capacity of batching plant, transit mixers and concrete pumps to be deployed by the bidder to achieve the required progress of work shall be specified in the relevant schedules of the bid documents.

The minimum grade of structural concrete shall be N25 (25 MPa compressive strength) conforming to AS 3600.

Blinding concrete below foundations and cable trenches shall be 75mm thick Plain Cement Concrete (PCC) with a minimum compressive strength of 10 MPa, and under brick foundations, a minimum 150mm thick PCC with a minimum compressive strength of 15 MPa (Grade N15).

Coarse and fine aggregates shall conform to AS 2758.1 and shall be specially selected to ensure that they are not susceptible to alkali/chloride attack or prone to disintegration at high temperatures. In particular, limestone aggregates shall never be used. The maximum size of the coarse aggregate shall not be larger than 1/8th of the narrowest dimension between reinforcement bars, nor more than 20 mm.

Washing and screening of coarse and fine aggregates to remove fines, dirt, or other deleterious materials shall be carried out by approved means if desired by the Employer.

The maximum water-cement ratio by weight shall be 0.45 or 0.50 as specified elsewhere, including moisture in the aggregates. The slump shall be suitably selected in accordance with AS 1379 and AS 3600 to provide good quality concrete work, as specified elsewhere in the specification.

Admixture

Admixtures may be permitted to be used in accordance with relevant codes to modify the rate of hardening or setting, to improve workability or as an aid to control concrete quality. The Employer reserves the right to direct the Bidder to conduct laboratory tests or use test data, or other satisfactory reference before granting approval. The cost of all tests conducted shall be borne by the Bidder. The admixture shall be used in strict accordance with the manufacturer's directions and/ or as directed by the Employer. No extra payment will be made to the Bidder on account of using admixtures.

Removal of air and water at the form surface shall be by vibration and rodding. Particular attention shall be paid to accurately shape the corners at the openings.

Point of discharge of the concrete in to the forms shall be 1500 mm above the concrete surface. Concrete shall be deposited in layers of approximately uniform level not greater than 400 mm deep unless permitted otherwise.

Sampling and testing of concrete shall be carried out as stated elsewhere in Technical Specification and as per AS 1012 (Methods of testing concrete).

Cover to Reinforcement

Unless indicated otherwise the clear concrete cover for reinforcement shall be as per Codes.

The correct cover shall be maintained by cement mortar cubes or other approved means. Reinforcement for footings/ pile caps, grade beam, and slabs on subgrade shall be supported on precast concrete cover block as approved by Employer. The use of pebbles or stones as cover blocks shall not be permitted.

The 28 days crushing strength of cement mortar cubes/ precast concrete cover block shall be atleast equal to the specified strength of concrete in which the cubes/ blocks are embedded.

The minimum clear distance between reinforcing bars shall be in accordance with **AS 3600** (or **NZS 3101**) (latest edition) or as specified elsewhere in this specification. All lapping of reinforcement bars shall be by lapping as per relevant codal provisions. Prior approval of the Employer shall be taken for deciding the method of lapping the reinforcement bars.

MATERIALS

Cement

General Purpose (Type GP) Portland cement or General Purpose Blended (Type GB) cement conforming to AS 3972, with a minimum 28-day compressive strength of 43 N/mm^2 (MPa), shall be used for all concrete construction. However, in place of pre-blended Type GB cement, Type GP cement at the batching plant can be used. The batching plant shall have the facility for mixing in accordance with AS 1379.

Aggregates

a) Coarse aggregate - Coarse aggregate for concrete shall be chemically inert, hard, strong, durable against weathering, of limited porosity, and free from deleterious materials. It shall be properly graded and meet the requirements of AS 2758.1.

b) Sand - Sand shall be hard, durable, clean, and free from adherent coatings of organic matter and clay balls or pellets. Sand, when used as fine aggregate in concrete, shall conform to AS 2758.1. For plaster and masonry work, the sand shall conform to AS 2758.6 and the material requirements of AS 3700.

Reinforcement Steel

All reinforcement bars shall be deformed bars of Grade 500N or Grade 500E (where higher seismic ductility is required) conforming to AS/NZS 4671. The ductility class and minimum percentage elongation shall satisfy the respective requirements of the standard.

Mild steel plain bars and hard-drawn steel wire shall conform to AS/NZS 4671 (Grade 250N for mild steel bars). Welded wire reinforcing mesh/fabric shall also conform to AS/NZS 4671.

Structural Steel

Structural steel (including embedded steel) shall be straight, sound, free from twists, cracks, flaws, laminations, and all other defects. Structural steel shall be of tested quality and shall conform to AS/NZS 3679.1 (for sections) and AS/NZS 3678 (for plates). Standard structural steel shall be a minimum of Grade 300. Higher strength structural steel conforming to Grade 350 may also be used in place of Grade 300.

Chequered (floor) plates shall conform to AS/NZS 3678, and pipes for handrails shall conform to AS/NZS 1163 (minimum Grade C250 Circular Hollow Sections).

All gratings shall be pressure-locked/electroforged and comply with the safety and structural requirements of AS 1657. The minimum thickness of the grating shall be 40 mm. The opening size shall not be more than 30 mm x 100 mm. The minimum thickness of the main bearing bar shall be 3 mm.

All gratings located inside the building shall be abrasive blast-cleaned to a Class 2.5 finish in accordance with AS 1627.4 and provided with two coats of suitable primer and two coats of finish paint, in accordance with an approved painting system conforming to AS/NZS 2312.1.

All gratings located outside the building shall be hot-dip galvanized with a minimum coating mass of 610 g/m^2 in accordance with AS/NZS 4680.

The supply of all structural steel shall be in the Bidder's scope.

Bricks

Standard concrete masonry units (CMU) conforming to AS/NZS 4455.1 shall be used for all structural masonry

In case bricks with a compressive strength of 7.5 MPa are not available, the bidder may alternatively use hollow concrete masonry units (minimum compressive strength of

25 MPa) for superstructure works, and solid concrete masonry units (minimum compressive strength of 25 MPa) for substructure works. All concrete masonry units shall conform to AS/NZS 4455.1.

Water

Water used for cement, concrete, mortar, plaster, grout, washing of coarse aggregates, soaking of bricks, etc., shall be clean and free from oil, acids, alkalis, organic matter, or other harmful substances in such amounts that may impair the strength or durability of the structure.

Potable water shall generally be considered satisfactory for all masonry and concrete works, including curing. The Bidder shall carry out necessary tests in advance to prove the suitability of the water proposed to be used. When water from the proposed sources is used for making the concrete, the maximum permissible impurities, development of strength, and initial setting time of the concrete shall meet the requirements of AS 1379 and AS 3600.

STATUTORY REQUIREMENTS

The Bidder shall comply with all applicable statutory rules about the Health and Safety at Work Act 1996 (Fiji), the Fire Safety regulations of the National Fire Authority (NFA) of Fiji, the Fiji National Building Code (FNBC), the Environment Management Act 2005 for pollution control, and relevant Fiji legislation for hazardous materials and explosives.

Provisions for safety, health, and welfare according to the Health and Safety at Work Act 1996 shall be strictly complied with. These shall include the provision of a continuous walkway of a minimum 500mm width along the crane-girder level on both sides of the building/pump house, a safe and comfortable approach to the EOT crane cabin, railings, fire escapes, toilets, etc., all designed in accordance with AS 1657 and the FNBC.

Statutory clearances, Environmental Impact Assessment (EIA) conditions, and the norms of the Fiji Department of Environment (DoE) shall be strictly followed.

The Bidder shall obtain the approval of Civil and Architectural drawings from the relevant statutory authorities—including the local Municipal Council, the Department of Town and Country Planning (DTCP), the NFA, and the DoE—before taking up any construction work.

GEOTECHNICAL INVESTIGATION & FOUNDATION SYSTEM

The geotechnical investigation and Foundation system to be adopted for the switchyard area shall be as detailed elsewhere in the specification.

TESTS FOR MATERIAL / WORKMANSHIP

All tests required for various bought-out items, materials, quality of workmanship, or any other tests as desired by the Project Manager and as specified in the technical specification shall be carried out by the Contractor at his own cost in the presence of the authorised representative of the Engineer.

The quality assurance checklists are given separately in respective chapters/sections of this specification. The Contractor shall submit a comprehensive Quality Assurance plan for all materials, equipment, workmanship, services, etc., and obtain approval from the Engineer. This shall include setting up a test laboratory at the site. However, such a checklist shall in no way limit the Contractor's liability and responsibility regarding the quality of workmanship as detailed in the specifications.

DRAWINGS

The successful Bidder shall first submit the structural design calculations along with general arrangement drawings for approval. After the approval of the design calculations by the Owner, detailed construction drawings shall be prepared and submitted for the Owner’s approval along with revised design calculations, if required, within 15 days. The Contractor shall submit the required number of sets of design calculations, drawings and documents. All documents, including design calculations, shall be prepared in MS Office, and all drawings shall be drafted using AutoCAD (Release 2000 or higher version). During every submission, one soft copy of the document shall also be submitted. When final approval is obtained from the Employer, the Contractor shall submit all the documents in TWO sets of CD-ROM (One + One Backup) together with a minimum of three sets of distribution prints, well-documented and page-controlled, with details of the Employer’s approval marked thereon. Approval of drawings/documents shall not relieve the contractor of the responsibility regarding the adequacy of design and correctness of drawings.

6. CODE & STANDARDS

All works shall be carried out as per the standards/codes (AS/NZS /IEC etc.) referred in the specification. All standards, specifications and codes of practice referred to shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those codes/standards referred the former shall prevail. All civil works should be carried out in conformity with AS/NZS & Fiji Building Code.

Equipment complying with other internationally accepted standards such as BS, UL, DIN, VDE etc. will also be considered, if they ensure performance and constructional features equivalent or superior to standards listed in the specification. In such case the Bidder shall clearly indicate the standards adopted, furnish a copy in the English of the latest revisions in force as on date of opening of bid and shall clearly bring out salient features for comparison.

The Works shall be constructed in accordance with the laws of Fiji and associated Acts and Regulations. These

include:

The Electricity Act (2017) and Electricity Regulations (2019)

Building Code of Fiji

Health and Safety at Work Act – 1996

Environment Management Act and subsidiary Regulations

In order to achieve Regulatory compliance under the Electricity Act, the Works shall comply with the Electricity Regulations and AS/NZS 3000:2018 “Wiring Rules”.

In the absence of specific standards being nominated in the specifications, the following standards shall apply:

PV Modules	
IEC 62804-1	Photovoltaic (PV) modules – Test methods for the detection of potential-induced degradation – Part 1: Crystalline Silicon
EN 50380	Datasheet and nameplate information of photovoltaic module.
IEC 61215 -1/ AS/NZS 61215:2021/2023	Terrestrial photovoltaic (PV) modules - Design qualification and type approval part 1: Tests Requirements
IEC 61215 -2 / AS/NZS 61215:2021/2023	Terrestrial photovoltaic (PV) modules - Design qualification and type approvalpart 2: Tests procedures
IEC 61701	Salt mist corrosion testing of photovoltaic (PV) modules
IEC 61730-1/2 / AS/NZS 61730.1& 2 :2024	Photovoltaic (PV) module safety qualification Part 1: Requirements for construction Part 2: Requirements for testing
IEC 61853-1	Photovoltaic (PV) module performance testing and energy testing – Part 1: Irradiance and temperature performance measurements and power rating
IEC 62790	Junction Boxes for photovoltaic modules-Safety requirements and tests

IEC 62994	Photovoltaic PV modules through the life cycle-Environmental health and safety(EH&S) risk assessment- General principles and nomenclature
IEC TS 62915	Photovoltaic (PV) modules - Type approval, design and safety qualification - Retesting
IEC 62941 / AS/NZS 62941:2023	Terrestrial photovoltaic (PV) modules - Guideline for increased confidence in PV module design qualification and type approval
IEC 62782	Photovoltaic (PV) modules - Cyclic (dynamic) mechanical load testing
IEC 62979	Photovoltaic modules - Bypass diode - Thermal runaway test
AS/NZS IEC 62716	Ammonia Corrosion Testing
AS/NZS 1170	Structural Design Actions
AS/NZS 1768	Lightning Protection
AS 1824	Insulation coordination – Definitions, principles and rules
AS/NZS 2373	Electric cables – Twisted pair for control and protection circuits
AS/NZS 3000	Wiring Rules

AS/NZS 5033:2021	Installation and safety requirements for PV arrays
AS/NZS 3000:2018	Electrical wiring rules

PV INVERTERS	
IEC 62894	Data sheet and name plate for photovoltaic inverters
IEC 61683	Photovoltaic Systems – Power conditioners – Procedure for measuring efficiency
IEC 62109-1	Safety of power converters for use in photovoltaic power systems Part1:General Requirements
IEC 62109-2	Safety of power converters for use in photovoltaic power systems-Part 2: Particular Requirements for inverters
IEC 62109-3	Safety of power converters for use in photovoltaic power systems-Part 3: Particular Requirements for Electronic Devices in Combination with Photovoltaic Elements
IEC 62891	Maximum Power Point Tracking Efficiency of Grid Connected Photovoltaic Inverters

IEC 62910	Test Procedure of Low Voltage Ride-Through (LVRT) Measurement for Utility interconnected PV Inverter
IEC 60529	Degree of protection provided by enclosures
IEC 62920 / AS/NZS 60529	EMC Requirements and Test methods for Grid Connected Power Converters applying to Photovoltaic Power Generating units
AS/NZS /IEC 62116:2020	Anti-islanding test procedure for grid-connected PV inverters
AS 4777.1:2024	Grid connection of energy systems via inverters - Part 1: Installation Requirements
AS/NZS 4777.2:2020 Amd 2:2024	Grid connection of energy systems via inverters - Part 2: Inverter requirements
AS/NZS 4777.3	Grid connection of energy systems via inverters - Part 3: Grid protection requirements
AS/NZS 61000 Series	EMC emission & immunity
AS/NZS 61000.3.6	Harmonic control in power systems
IEEE 1547 / IEC 61727 / IEEE 2800	Interconnection standard for distributed resources

GRID-CONNECTED PV SYSTEM	
IEC 60947	Connectors for photovoltaic systems - Safety.
IEC 61727	Photovoltaic (PV) systems - Characteristics of the utility interface
IEC 61836	Solar photovoltaic energy systems - Terms, definitions and symbols
IEC 62093	Balance-of-system components for photovoltaic systems
IEC 62446-1	Photovoltaic (PV) systems - Requirements for testing, documentation, and maintenance – Part 1: Grid-connected systems – Documentation, commissioning tests and inspection
IEC 61724 (all parts)	Photovoltaic System Performance Monitoring
IEC TS 63049	Terrestrial photovoltaic (PV) systems – Guidelines for effective quality assurance in PV systems installation, operation and maintenance
IEEE P1547	Series of Standards for Interconnection, May, 2003, NREL/CP-560-34003
AS/NZS 3008.1.1	Electrical installations – Selection of cables – Cables for alternating

	voltages up to and including 0.6/1 (1.2) kV.
AS 3011.2	Electrical installations – Secondary batteries installed in buildings, Part 2: Sealed cells
AS/NZS 3080	Telecommunications installations - Generic cabling for commercial premises
AS/NZS 3155	Approval and test specification - Electric cables - Neutral screened – For working voltages up to and including 0.6/1 kV
AS/NZS 3191	Electric flexible cords
AS/NZS 3439.1	Low voltage switchgear and control gear assemblies
AS/NZS 3439.2	Low-voltage switchgear and control gear assemblies - Particular requirements for busbar trunking systems (busways)
AS/NZS 3835	Earth potential rise - Protection of telecommunications network users, personnel and plant
AS/NZS 3947	Low voltage switchgear and control gear, (all relevant parts)
GENERAL ENGINEERING STANDARDS	
BS 7354	Code of Practice for Design of high voltage open terminal stations

BS 7430	Code of Practice for Protective Earthing of electrical installations
EN 50521	Connectors for photovoltaic systems - Safety.
IEC 60068-2	Environmental testing of specimen to withstand specific severities of repetitive and non- repetitive nature
IEC 60076	Power transformers - ALL PARTS
IEC 60228	Conductors of Insulated Cables
IEC 60364-1	Electrical installations of buildings - Part 1: Scope, object and fundamental principles
IEC 60364-5-54	Electrical installations of buildings. Part 5: Selection and erection of electrical equipment. Chapter 54: Earthing arrangements and protective conductors
IEC 60364-5-55	Electrical installations of buildings
IEC 60502-1	Power Cables with extruded insulation and their accessories for rated voltages from 1 kV (Um – 1.2 kV) up to 30 kV (Um = 36 kV) Part 1 - Cables for rated voltages for 1 kV (Um=1.2 kV) and 3 kV (Um=3.6 kV)

IEC 60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Un= 36 kV) up to 150 kV (Un = 170 kV)- Test methods and requirements
IEC 60664-1	Insulation coordination for equipment within low-voltage systems –Part 1: Principles, requirements and tests
IEC 60909-1	Short circuit calculation in three-phase ac systems.
IEC 62208	General requirements for empty enclosures for low voltage switchgear and control gear assemblies
IEC 62305-3	Protection against lightning, part 3 physical damage and life hazards in structures
IEEE C37.90	IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus
IEC 60529	Degree of protection provided by enclosures
AS 4024.1	Safety of machinery, (all relevant parts)
AS/NZS 4026	Electric cables - For underground residential distribution systems

AS 60529	Degrees of protection provided by enclosures (IP Code)
AS/NZS 60898	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Circuit-breakers for a.c. operation
AS HB101	Coordination of power and telecommunications - Low Frequency Induction (LFI): Code of practice for the mitigation of hazardous voltages induced into telecommunications lines.
AS 1345	Identification of the contents of pipes, conduits and ducts
AS/NZS 2053	Conduits and fittings for electrical installations (all parts)
AS 2700	Color standards for general purpose
IEC 11801	Information technology – Generic cabling for customer premises
IEC 14763	Information technology – Implementation and operation of customer premises cabling
IEC 24702	Information technology – Generic cabling – Industrial premises
IEC 60269	Low-voltage fuses

IEC 60304	Standard colours for insulation for low frequency cables and wires
IEC 60364	Electrical installations of buildings
IEC 60934	Circuit breakers for equipment
IEC 61009	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)
IEC 61089	Round wire concentric lay overhead electrical stranded conductors
IEC 61232	20SA/A Aluminium clad wires for electrical purposes
BS EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles
BS 6231	Specification for PVC-insulated cables for switchgear and control gear wiring
BS 6651	Protection of structures against lightning.
BS 7354	Code of Practice for Design of high-voltage open-terminals stations, Section 7: Earthing.
BS 7430	Code of Practice for Earthing
Power Quality	
IEC 61000-3-2	Limits - Limits for harmonic current emissions (equipment input

	current up to and including 16 A per phase)
IEC 61000-3-3	Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection
IEC 61000-3-7	Assessment of emission limits for the connection of the connection of fluctuating installations to MV, HV and EHV power systems
IEC 61000-3-11	Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current ≤ 75 A and subject to conditional connection.
IEC 61000-6-1	Generic standard -EMC - Susceptibility - Residential, Commercial and Light industry
IEC 61000-6-3	Generic standard - EMC - Emissions - Residential, Commercial and Light industry
IEC 61000-6-5:	Electromagnetic compatibility (EMC) - Generic standards - Immunity for power station and substation environments
IEC TR 61000-3-6	Assessment of emission limits for the connection of distorting installations to MV,

	HV and EHV power systems
IEEE519	IEEE Recommended practice and requirements for harmonic control of electric power systems, Institute of Electrical and Electronic Engineers.

Standards Applicable for Civil part	
AS/NZS 3679.1	Structural steel - Hot-rolled bars and sections
AS/NZS 4600	Cold-formed steel structures
AS/NZS 1163	Cold-formed structural steel hollow sections
AS/NZS 1163	Cold-formed structural steel hollow sections
AS/NZS 4680	Hot dip galvanized (zinc) coatings on fabricated ferrous articles
AS/NZS 4792	Hot dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialized process
AS 1231	Aluminium and aluminium alloys - Anodised coatings for architectural applications
AS/NZS 4680	Hot dip galvanized (zinc) coatings on fabricated ferrous articles
AS 1397	Continuous hot-dip metallic coated steel sheet and strip
AS/NZS 2312 Series	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings

AS/NZS 2312	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
AS 1940	The storage and handling of flammable and combustible liquids
AS 2067	Substations and high voltage installations

BESS Standards	
AS IEC 62619:2023	Safety requirements for secondary Li-ion cells and batteries (industrial applications)
IEC 61427-2	Secondary batteries for on-grid renewable energy storage
IEC 63056	Safety requirements for Li cells in EES systems
UN 38.3	Safe transport of lithium cells and batteries
IEC 61882	HAZOP studies
AS/NZS 4509	Stand-alone power systems
AS/NZS 5139:2019 Amd 1:2025	Electrical installations – Safety of battery systems for use with power conversion equipment

7. TERMINAL POINT AND EXCLUSIONS

7.1 ELECTRICAL INTERFACES

TERMINAL POINT

The Bidder shall terminate project output in accordance with Tender SLD. All hardware & services required for 33kV LILO connection from adjacent Transmission line is considered in the scope of Bidder.

7.2 CIVIL INTERFACES

TERMINAL POINT

All Internal Roads and Drains are in Bidder Scope and shall be constructed and connected suitably with Approach Road and External/Natural drainage/ outfall, by the Bidder.

Approach road for the project shall be in the contractor's scope as marked in the Vicinity map.

Any arrangement like temporary fencing for safety and security of the project as well as any storage arrangement etc. during construction & O&M period would be in Bidder Scope. All temporary arrangements w.r.t approach roads, drainage, office set up etc. as necessary to take up the project construction work, would be in bidder's scope.

8. Employer Submission Requirements

8.1 Company Profile & Experience — Bidder Submission Requirements

Each Bidder shall submit comprehensive documentation establishing its legal standing, financial strength, technical capability, and relevant track record in delivering utility-scale Solar PV and Solar+BESS hybrid projects. The Employer (Energy Fiji Limited) will use this information to assess Bidder eligibility and pre-qualification prior to detailed technical/commercial evaluation.

Legal & Organizational Information

Item	Required Submission
Certificate of Incorporation	Copy of certificate of incorporation/registration in country of origin, and Fiji business registration/branch registration if applicable
Power of Attorney	Authorisation of the signatory executing the bid on behalf of the Bidder
Organisation Chart	Corporate structure, including parent company, subsidiaries, and proposed project organisation chart with key personnel
Litigation / Debarment History	Declaration of any pending litigation, arbitration, blacklisting, or debarment by any government/multilateral agency in the past 5 years

Financial Strength

Item	Required Submission
Audited Financial Statements	Audited balance sheet and profit & loss statements for the last 3 financial years

Item	Required Submission
Banker's Solvency Certificate	Confirming financial capacity to execute a project of this scale and value
Line of Credit / Financing Capability	Evidence of access to working capital and, where applicable, arrangement for concessional/project financing (e.g., multilateral or export credit agency backing)
Bid Security / Bank Guarantee Capacity	Confirmation of ability to furnish Bid Bond and Performance Bank Guarantee as specified in the tender conditions

8.2 Technical Proposal — Bidder Submission Requirements

Project Understanding

The Bidder shall submit a concise written narrative demonstrating a clear understanding of the 12 MWac (14 MWp DC) ground-mounted Solar PV Plant integrated with a 6 MW / 12 MWh Battery Energy Storage System (BESS) at Seaqaqa, Vanua Levu, Fiji, as described in the Detailed Feasibility Report.

The narrative shall confirm the Bidder's understanding of:

The development, design, engineering, procurement, construction, testing, commissioning, and integration of the Solar PV and BESS facilities, including associated electrical, civil, structural, SCADA, EMS, communication, and balance-of-plant systems.

The Project's interconnection to the Labasa Grid via a 33 kV Line-In Line-Out (LILO) arrangement, including compliance with EFL grid requirements and associated protection, control, metering, and grid stability obligations.

The characteristics of the islanded Labasa power system, including its dependence on diesel and seasonal bagasse-based generation, peak demand of approximately 8–10 MW, limited system inertia, and the critical role of the BESS in frequency regulation, voltage support, peak shaving, renewable integration, spinning reserve, and black-start capability.

Site-specific conditions at Seaqaqa, including approximately 26.47 ha of available land, flood-prone low-lying areas, natural drainage channels, undulating terrain requiring earthworks and grading, high-plasticity soils, high soil corrosivity requiring C5 corrosion protection, exposure to Category 5 cyclones, and location within Seismic Zone 6, all of which shall be incorporated into the project design and execution approach.

The tropical marine environment of Vanua Levu, characterized by high solar irradiation, high humidity, significant rainfall, cyclone exposure, and corrosive conditions affecting equipment selection, structural design, durability, and long-term asset performance.

The narrative shall demonstrate how the Bidder has considered these technical, environmental, operational, and site-specific requirements in its proposed design philosophy, construction methodology, risk mitigation measures, and overall project delivery strategy to ensure a safe, resilient, and reliable Solar PV and BESS facility.

Design Philosophy & Engineering Methodology

The Bidder shall submit a **Design Philosophy & Engineering Methodology** outlining the proposed approach for the design of the **12 MWac Solar PV Plant and 6 MW/12 MWh BESS**, including the design basis, applicable codes and standards, site constraints, and key engineering assumptions.

The submission shall describe the methodology for developing the optimized plant layout, electrical SLD up to the 33 kV LILO interconnection point, energy yield assessment (P50/P75/P90), and confirmation of the BESS sizing and grid-forming control philosophy for the islanded Labasa Grid.

The methodology shall further explain how geotechnical conditions, flood risks, soil corrosivity, cyclone loading (85 m/s), and Seismic Zone 6 requirements have been incorporated into the civil, structural, and foundation designs. In addition, the Bidder shall provide the proposed SCADA/EMS architecture, communication philosophy, and integration approach with EFL systems to ensure reliable, safe, and efficient plant operation.

Quality Assurance / Quality Control (QA/QC):

The Bidder shall submit a Project-Specific Quality Assurance and Quality Control (QA/QC) Methodology describing the systems, procedures, and controls that will be implemented throughout design, procurement, manufacturing, construction,

testing, commissioning, and handover of the Project. The submission shall include a Project Quality Assurance Plan (QAP) covering design verification and review processes, supplier quality management, manufacturing surveillance, Factory Acceptance Testing (FAT), site quality control procedures, inspection hold points, testing requirements, audit procedures, and non-conformance reporting and corrective action management.

The Bidder shall provide Inspection and Test Plans (ITPs) for major civil, structural, electrical, SCADA/communication, and BESS works, identifying inspection stages, acceptance criteria, witness points, testing requirements, and documentation to be maintained. The Bidder shall also submit a methodology describing how compliance with the specified EMS, PPC, and grid-support functions will be verified, including grid-forming operation, black-start capability, frequency regulation, voltage control, droop control, spinning reserve response, and transitions between operating modes. The methodology shall also describe arrangements for third-party inspection and testing of critical equipment, including PV modules, inverters, transformers, switchgear, BESS containers, and protection systems, where applicable.

The submission shall further describe the proposed material traceability system for major equipment and components, including unique identification and tracking of PV modules, cables, structures, and BESS equipment, together with calibration, verification, and maintenance procedures for all testing and commissioning instruments. The Bidder shall demonstrate how the proposed QA/QC framework will ensure compliance with Contract Requirements, applicable standards, and long-term reliability and performance of the Solar PV and BESS facility.

Health, Safety & Environment (HSE) Approach

The Bidder shall submit a Project-Specific Health, Safety and Environment (HSE) Methodology describing the management systems, procedures, and controls that will be implemented during engineering, procurement, construction, testing, commissioning, and handover of the Project. The submission shall include an HSE Management Plan demonstrating compliance with applicable Fiji legislation and international industry best practices, including hazard identification, risk assessment, training, incident reporting, permit-to-work systems, emergency preparedness, and contractor management procedures.

The Bidder shall describe the proposed BESS safety and emergency response strategy, including fire detection and suppression systems, thermal runaway prevention and mitigation measures, emergency response protocols, and coordination with relevant authorities. The methodology shall also address

vegetation and bushfire risk management, site housekeeping, and maintenance of required asset protection zones in accordance with applicable standards.

The submission shall further include the Bidder's approach to managing cyclone and severe-weather risks during construction, including workforce safety, temporary works protection, material storage, and equipment securing procedures. In addition, the Bidder shall provide an Environmental Management Plan (EMP) outlining measures for erosion and sediment control, drainage management, dust and noise control, waste management, pollution prevention, protection of natural drainage paths, and environmental monitoring to ensure compliance with applicable environmental regulations and project-specific requirements.

8.3 Assumptions, Calculations & Drawings — Deliverables Checklist

Deliverable	Stage
Basis-of-design assumptions register (resource data, degradation, losses)	Bid stage
Preliminary GA layout & SLD	Bid stage
Detailed engineering drawings (civil, structural, electrical, SCADA)	Post-award, prior to procurement
Load flow, short-circuit & protection coordination study	Post-award
Cable sizing & voltage drop calculations	Post-award
Foundation design calculations	Post-award
As-built drawings	Post-commissioning

Deliverable	Stage
O&M manuals and spare-parts catalogues	Prior to handover

8.4 Commercial Proposal

Pricing Structure & Bill of Quantities (BOQ)

Bidders shall submit a fully priced BOQ broken down by major work package, in the format below at minimum. Pricing shall be prepared in accordance with Clause 15 (Tender Currency) of Section 1. All prices shall be quoted on a landed, DAP (previously referred to as Delivery Duty Unpaid (DDU)), or as otherwise specified by EFL. Local taxes and duties shall be identified separately.

Sl. No.	Work Package / Item	Unit	Qty	Unit Rate (USD)	Total (USD)
1	Solar PV System (modules, inverters, MMS) – 12 MWac/14 MWp	Lot	1	[Bidder to quote]	[Bidder to quote]
2	BESS (6 MW/12 MWh) incl. PCS, containers, HVAC, EMS/SCADA	Lot	1	[Bidder to quote]	[Bidder to quote]
3	Balance of System (DC/AC cabling, transformers, switchyard, earthing, civil works)	Lot	1	[Bidder to quote]	[Bidder to quote]
4	Site preparation & earthwork	Lot	1	[Bidder to quote]	[Bidder to quote]
5	Logistics (packing, forwarding, sea freight, inland transport)	Lot	1	[Bidder to quote]	[Bidder to quote]

Sl. No.	Work Package / Item	Unit	Qty	Unit Rate (USD)	Total (USD)
6	Installation, testing & commissioning	Lot	1	[Bidder to quote]	[Bidder to quote]
7	SCADA/EMS integration & grid interconnection works	Lot	1	[Bidder to quote]	[Bidder to quote]
8	O&M per annum (For 3 Years post-handover)	Lot	1	[Bidder to quote]	[Bidder to quote]
9	Training (per Section 6)	Lot	1	[Bidder to quote]	[Bidder to quote]
10	Spare parts (commissioning/mandatory spares)	Lot	1	[Bidder to quote]	[Bidder to quote]

Payment Milestones — Bidder to Propose, Subject to EFL Approval*

Milestone	Indicative % of Contract Price
Advance payment (against Advance Payment Bank Guarantee)	10%
Approval of detailed engineering drawings	10%
Dispatch of Equipment	25%
Delivery of major equipment to the site	10%

Milestone	Indicative % of Contract Price
Completion of installation / mechanical-electrical completion	15%
Provisional Acceptance Certificate (PAC) / successful commissioning	15%
Final Acceptance Certificate (FAC), post Defect Liability Period	10%

***To be finalised by EFL**

8.5 Project Timeline

The Bidder shall submit a detailed **Project Execution Schedule** clearly identifying all major project activities, milestones, interfaces, and critical paths from Notice to Proceed (NTP) through Provisional Acceptance and Final Acceptance. The schedule shall include engineering and design activities, approvals and permits, procurement, manufacturing, Factory Acceptance Testing (FAT), logistics and delivery, site mobilization, civil works, structural erection, electrical and BESS installation, SCADA/EMS integration, testing and commissioning, performance testing, training, and handover.

8.6 Operation & Maintenance (O&M) Plan

The Bidder shall submit a comprehensive **Operation & Maintenance (O&M) Plan** describing the proposed strategy, organization, resources, and procedures for ensuring the safe, reliable, and efficient operation of the Solar PV and BESS facility throughout the O&M period. The submission shall include the proposed O&M organization structure, staffing plan, roles and responsibilities, spare parts philosophy, maintenance facilities, and response times for corrective maintenance activities.

The O&M Plan shall describe the methodology for preventive, predictive, condition-based, and corrective maintenance of all major plant components, including PV modules, module mounting structures, inverters, transformers, switchgear, SCADA/EMS systems, communication infrastructure, BESS equipment, fire protection systems, drainage systems, roads, and security facilities. The Bidder shall also describe the proposed plant monitoring, performance analysis, fault management, degradation tracking, vegetation control, cleaning strategy, warranty management, and reporting procedures.

The submission shall further include the proposed availability guarantees, performance monitoring framework, emergency response arrangements, spare parts inventory management, training of Employer personnel, cybersecurity maintenance measures, and lifecycle asset management strategy. The O&M methodology shall demonstrate how long-term plant reliability, safety, energy yield, and BESS performance will be maintained in the tropical, cyclonic, and high-corrosion environment of Vanua Levu while ensuring compliance with all applicable contractual, regulatory, and grid-operational requirements.

8.7 O&M Training Plan

The Bidder shall submit a comprehensive **O&M Training Plan** demonstrating how EFL personnel will be trained and equipped to safely, effectively, and independently operate, monitor, troubleshoot, and maintain the Solar PV and BESS facility following project handover. The training program shall cover all major plant systems, including Solar PV generation, BESS, transformers, switchgear, protection systems, SCADA, EMS, communication networks, fire protection systems, and auxiliary facilities.

Particular emphasis shall be placed on training related to the **grid-forming BESS architecture**, including Virtual Synchronous Generator (VSG) functionality, voltage-frequency droop control, black-start capability, frequency and voltage regulation, EMS dispatch logic, and coordination with diesel & bagasse generation within the islanded Labasa Grid. The Bidder shall describe the proposed training methodology, duration, training materials, classroom and practical sessions, simulator or on-site operational training, competency assessments, and knowledge-transfer procedures to ensure EFL personnel are capable of safely operating and maintaining the facility throughout its operational life.

8.8 Documentation to be Provided post commissioning and handover

The Bidder shall provide, at a minimum, the following documentation in English, in both hardcopy and editable electronic format:

i. Operation & Maintenance (O&M) Manuals for:

a. Solar PV

b. Battery Energy Storage System (BESS)

c. SCADA

d. Energy Management System (EMS)

e. Protection Systems

f. Transformers

g. Switchgear

h. Communication Systems

i. Fire Protection Systems

j. Balance of Plant (BoP)

ii. As-Built Documentation, including:

a. General Arrangement Drawings

b. Plant Layout Drawings

c. Electrical Layout Drawings

d. Cable Routing Drawings

e. Earthing and Lightning Protection Drawings

f. Structural and Civil Drawings

iii. Electrical System Documentation, including:

a. Single Line Diagrams (SLDs)

b. Protection Coordination Studies

c. Relay Setting Reports

d. Grid Integration Studies

e. Load Flow and Short-Circuit Reports

iv. SCADA, EMS and Control System Documentation, including:

a. SCADA Architecture Drawings

b. EMS Functional Description

c. Communication Network Diagrams

d. Control Philosophy Documents

e. Grid-Forming/Virtual Synchronous Generator (VSG) Control Philosophy

f. System Configuration and Settings Files

v. Equipment Documentation, including:

a. Equipment Datasheets

b. Manufacturer Manuals

c. Factory Acceptance Test (FAT) Reports

d. Site Acceptance Test (SAT) Reports

e. Calibration Certificates

f. Warranty Certificates

g. Spare Parts Catalogues

h. Asset Registers

vi. Commissioning and Performance Documentation, including:

a. Commissioning Procedures and Reports

b. Performance Test Reports

c. Reliability Run Records

d. Final Acceptance Test Documentation

vii. Standard Operating Procedures (SOPs) covering:

a. Normal Operation

b. Start-up and Shutdown

c. BESS Charge/Discharge Operation

d. Grid-Forming and Grid-Following Modes

e. Black-Start Procedures

f. Abnormal and Emergency Conditions

g. Grid Disturbance and Restoration Procedures

viii. Maintenance Documentation, including:

a. Preventive Maintenance Schedules

b. Corrective Maintenance Procedures

c. Inspection Checklists

d. Maintenance Log Sheets

e. Troubleshooting Guides

f. Equipment History Records

ix. Health, Safety and Environmental (HSE) Documentation, including:

a. Safety Data Sheets (SDS)

b. Emergency Response Plans

c. Fire and Thermal Runaway Response Procedures

d. Cyclone and Flood Response Procedures

e. Evacuation Plans

f. Environmental Monitoring and Incident Reporting Forms

x. Training and Handover Documentation, including:

a. Training Materials and Presentations

b. Attendance Records

c. Competency Assessment Reports

d. Training Completion Certificates

e. Consolidated Competency Register for EFL Personnel

Minimum Technical Specification of Major Equipment of Solar+BESS Project at Seaqaqa, Fiji

9. DC System

9.1 SOLAR PHOTOVOLTAIC (SPV) MODULES

9.1.1 GENERAL

The Solar PV module comprises of PV cell(s) connected in any combination to achieve the required module power output. PV cells directly produces DC power on receipt of solar irradiation.

CRYSTALLINE SILICON MODULES (C-Si)

The PV cells in a crystalline silicon module shall be protected by encapsulation between front glass and back sheet/back glass. The glass shall be made of high transmissivity and front surface shall give high encapsulation gain.

The technical details of Solar PV Modules shall be as given below.

Sl. No.	Description	Details
1	Type of SPV Module	Crystalline Silicon
2	Peak Power rating of Module	Shall not be less than **550 Wp**
3	Module Efficiency	Minimum **22** % at Standard Test Conditions
4	Fill Factor	**0.75(Minimum)**

9.1.2 CODES AND STANDARDS

Solar PV module shall be commercial, off-the -self product, UL Listed and meeting following IEC standards:

Codes	**Description**
IEC 61215-1-2021	Terrestrial Photovoltaic (PV) Modules – Design qualification and type approval Part 1 – Test Requirements
IEC 61215-1-1:2021	Special requirements for crystalline-silicon PV modules

IEC 61215-2: 2021	Terrestrial Photovoltaic (PV) Modules – Design qualification and type approval Part 2 – Test Procedures
IEC 61853	Photovoltaic (PV) Module Performance Testing and Energy Rating
IEC 61730 – 1 - 2023	Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction
IEC 61730 – 2 - 2023	Photovoltaic (PV) module safety qualification – Part 2: Requirements for Testing
IEC 61701 – Edition 2.0 2020	Salt mist corrosion testing of photovoltaic (PV) modules
IEC 62804 – 1: 2020	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon
IEC 60364-7-712:2025 IEC 60364	Electrical installation of photovoltaic (PV) systems

9.1.3 TECHNICAL REQUIREMENTS

- Bidder must follow the Fiji legislation, National Building Code and Fiji Wind loading standard to calculate the module wind pressure rating. However, wind speed shall be minimum 85 m/sec or actual (whichever is higher) is to be considered for calculation. The PV module shall have a certified design load equal to or greater than the maximum positive and negative design pressure determined by the project structural engineer for each array zone. The corresponding module test load shall include the applicable safety factor required by IEC 61215/IEC 61730 and the manufacturer's certification basis.

- The module shall successfully complete the cyclic dynamic mechanical-load test under IEC 61215-2:2021, using a load level consistent with the selected module design-load rating. Test reports shall include pre-test and post-test electroluminescence images, insulation testing, wet-leakage testing and maximum power degradation.

- The PV modules, module clamps, rails, mounting tables, foundations, fasteners and all structural connections shall be designed for the site-specific cyclonic wind actions determined in accordance with the applicable Fiji National Building Code, the latest Fiji-adopted wind-loading standard and AS/NZS 1170.2:2021 including all applicable amendments, read in conjunction with AS/NZS 1170.0

- The minimum ultimate regional wind speed for design shall be 85 m/s or the higher value determined by the project-specific wind-hazard assessment and competent Fiji authority. Terrain, height, shielding, topographic, direction, aerodynamic, edge-zone, corner-zone and dynamic effects shall be included.

- PV-module positive and negative design pressures shall be determined for every array zone. The certified module design-load resistance shall not be less than the calculated factored design pressure. The associated module test load shall include the safety factor applicable to IEC 61215 and IEC 61730 certification.

- As a minimum tender requirement, the offered module shall have certified mechanical test loads of +5400 Pa on the front surface and −4000 Pa on the rear surface. Preference shall be given to modules certified to at least −5400 Pa rear load. These minimum values shall not relieve the Contractor from demonstrating adequacy against the final project-specific design pressures.

- Mechanical-load certification shall be valid for the exact module frame, clamp locations, clamp lengths, fastening arrangement, support-rail spacing and module orientation proposed for the Works. Third-party test reports and mounting drawings shall be submitted for approval.

- Modules shall comply with IEC 61215-1:2021, IEC 61215-1-1:2021, IEC 61215-2:2021, IEC 61730-1:2023, IEC 61730-2:2023, IEC 61701:2020 Edition 3.0 and IEC TS 62804-1:2025, as applicable.

- For coastal exposure, the module, frame, connectors, junction box, clamps, fasteners and mounting structure shall be suitable for the specified marine-corrosivity category and salt-mist severity. Dissimilar-metal contact shall be prevented by suitable material selection or electrical isolation

- The temperature co-efficient of Power for the module should be better than -0.40% per deg C. Each and every SPV module shall conform to standards mentioned in clause 2.2 above and no negative power tolerance shall be accepted. Additionally, the Module wattage band/bin offered shall not be less

than 5Wp. Each inverter shall use only one type (Make and Nominal rating) of module.

- Module shall be made up of mono crystalline silicon cells. The module should be PID resistant. The glass (front and back) used to make the crystalline silicon modules shall be Heat strengthened low iron glass with minimum thickness of 2.0mm +/- 0.2 mm for glass-to-glass framed modules. Grid printed back glass shall be preferred for glass-to-glass framed modules.

- The glass used shall have transmittance of above 90% and with bending less than 0.3% to meet the specifications.

- The module shall not be subjected to any point load during transportation, handling and erection and complete care has to be taken to avoid any undue loading on either side of the module.

- The interconnected cells shall be laminated in vacuum to withstand adverse environmental conditions. The encapsulant (combination of EPE and/or POE) used for the modules should be of UV resistant and PID resistant in nature with gel content of minimum 75%. EVA encapsulant is not permitted.

- The module frame shall be made of corrosion resistant materials, preferably having aluminum anodized finish. The anodizing thickness shall be 15 microns or better. In case the offered module is frameless, suitable retaining clips/clamps used for installing the modules shall not damage the glass surface in contact with the retaining clamp.

- Module(s) shall be provided with minimum three (03) bypass diode.

- Junction box(es) of the module should be of high quality IP 68 or better rated fitted at the back side which should be weather proof and designed to be used with standard wiring or conduit connection. Each Junction Box shall contain Bypass Diode. The reverse current withstand to be minimum 50A and flammability class to be minimum UL94-V0, 5VA. Additionally, JB enclosure height to be such that it will cause minimum shadow to fall on adjacent cells and cause hotspot. It is to be ensured that the Modules installed on MMS Table, in two rows, , should be connected so as to minimize the shading effect. For Fixed Type MMS, the same is to be achieved by connecting the modules in the upper row of consecutive tables in series. Similarly, the modules in the lower row are to be connected in series and to be kept separate from the modules in the upper row.

9.1.4 COMMON REQUIREMENTS FOR CRYSTALLINE SILICON (C-Si)

- SPV module shall perform satisfactorily with ambient temperatures between -10°C & +60°C and shall be able to withstand mechanical load as per IEC requirement.

- Solar PV modules used in solar power plants/ systems must be warranted for the product Workmanship for a period of minimum 12 years. Further, they shall also be warranted for their output peak output peak watt capacity, which should not be less than 95% at the end of 10 years and 85% at the end of 30 25 years from the date of receipt of last batch/lot of equipment at site.

- The bidder shall provide the sample solar PV module electrical characteristics including current-voltage (I-V) performance curves and temperature coefficients of power, voltage and current.

- The minimum design clearance (at the highest tilt angle) between the lower edge of the modules and the developed ground level shall be as specified in Appendix-1 of Part-A, Chapter 1-A. A tolerance of +/-50mm shall be allowed as per site conditions

- Each PV module deployed must use a Radio Frequency identification (RFID) tag for traceability. RFID shall either be placed behind name plate sticker or behind bar code label pasted on the back glass of PV module and must be able to withstand harsh environmental conditions during the module lifetime. One number RFID reader has to be supplied by the bidder which has to be compatible to read the data from the RFID Tag & download the data to Computer. All associated Software & Cables are to be provided along with the RFID reader. The following information must be mentioned in the RFID used on each module.

    i. Name of the manufacturer – PV Module
    ii. Name of the Manufacturer of Solar cells
    iii. Month & year of the manufacture of the module (separately for solar cells and module)
    iv. Country of origin (separately for solar cells and module)
    v. I-V curve for the module at STC
    vi. Wattage, Im, Vm and FF for the module
    vii. Unique Serial No. and Model No. of the module
    viii. Date and year of obtaining IEC PV module qualification certificate

ix. Name of the test lab issuing IEC certificate
x. Other relevant information on traceability of solar cells and modules as per ISO 9001

- All the modules in the PV plant should be arranged in a way so as to minimize the mismatch losses.

- Each module should have two suitably sized stranded UV resistant cables and terminated with DC plug-in connector directly. The positive (+) terminal has a male connector while the negative (-) terminal has a female connector. Any different design offered shall be reviewed during detailed engineering. The connectors used for interconnecting the modules and connectors used for connecting the strings and/or to the String combiner Box, i.e. field connectors shall be of same make for better compatibility (refer Connectors chapter elsewhere for detailed Specification of Field Connectors). In case, 1500 V modules are used, the connecting cable shall be as per the relevant standard.

- The bidder has to submit, along with the data sheet of the module, a detailed Bill of Material (BoM) elaborating on the properties, such as, thickness, material composition etc of the major components of the module which shall be same as per the type tested and approved Constructional Data Form (CDF).

9.1.5 NAME PLATE

All individual modules shall be provided with Name Plate label at the back of module which shall provide the information given below for identification. They shall be clearly visible and shall not be hidden by equipment wiring. Type of labels and fixing of labels shall be such that they are not likely to peel off/ fall off during the life of the panel.

- Manufacturer's Name
- Model Number, Serial Number
- Overall Dimensions (W x L x D)
- Weight (kg)
- Maximum Power (P_{MAX}), Voltage (V_{MP}), Current (I_{MP})
- Short Circuit Current (I_{SC}), Open Circuit Voltage (V_{OC})
- Main System Voltage
- Relevant standards, Certification lab. name
- TPCL EFL Logo on the top corner of each Module (Design shall be provided to successful bidder during detail engineering)

- Warnings, if any

9.1.6 TYPE TEST

SPV modules must be tested and certified by any of the accredited certifying agencies according to International Standards and the type test reports shall be submitted for approval.

Note:

1. The Module Manufacturer, along with the Module datasheet, shall also provide the Details about the PV Cells used for the offered PV Modules. The information shall contain Cell Source, Type, and Electrical Parameters including efficiency, Size, Number of Bus bars and any other relevant information**.** *(For Crystalline Silicon Modules)*

2. Bidder shall submit the following:

i. Third-party verified PAN files for any one module, if bidder is offering three wattage bins or less. In case the bidder is offering more than three wattage bins, additional PAN files for each additional wattage bin need to be submitted.

ii. Self-certified Electro- Luminescence (EL) Test reports of all the Crystalline Silicon based PV Modules being offered to TPCL.EFL

3. Module manufacturer should have IEC type test certificate to be issued by TUV, UL, Intertek, or CSA.

9.1.7 PACKING & TRANSPORTAION

- The contractor shall be responsible for securely protecting and packing the PV module as per prescribed standards in force to withstand the journey and ensuring safety and arrival of PV Modules at destination in original condition and good for contemplated use.

- The contractor shall ensure that all the solar modules in the pellets/boxes are securely packed and reinforced to withstand potential damage caused by road (or similar) conditions, including but not limited to bumps, potholes, and rough terrain.

- The stacking of PV module packages and/or pellets during loading and transportation shall be as per best industry standards to minimize breakage. The contractor shall provide appropriate padding or cushioning materials within the transportation vehicle to avoid the impact on the pellets/boxes. Additionally, the

packing arrangement of PV Modules and their pellets/boxes shall be in a manner to avoid relative motion of pellets/boxes during transportation.

- The bottom wooden frame/planks supporting the pellets should be sturdy and of sufficient strength to securely withstand pellet size and weight. Pellets/boxes shall be loaded in a manner to avoid touching the truck roof/trailer roof damaging the PV modules during unloading.

- Packing case size, weight and the pellet bottom supporting wooden frame/plank shall take into consideration the remoteness of the good's destination and absence of heavy material handling facilities at all points in transit.

- During supply, storage and transportation, all DC connectors on SPV module leads shall be fitted with protective end caps to prevent ingress of dust, moisture, water, insects and other contaminants. The end caps shall be compatible with the connector type, weather-resistant, and shall not damage the connector.

9.2 DC CABLES

The DC Cables in a solar PV plant are used in the following areas

i. Interconnecting SPV modules
ii. From SPV Modules upto SCB
iii. From SCB upto the Inverter.

9.2.1 DC CABLES (Interconnecting SPV MODULES and from SPV Modules TO SCB)

Each module shall have two 4 sq.mm stranded UV resistant cables and terminated with DC plug-in connector directly. The positive (+) terminal shall have a male connector while the negative (-) terminal a female connector. All the modules in the PV plant shall be arranged in a way so as to minimize the mismatch losses.

It is to be ensured by the contractor that the Modules installed on a MMS, should be connected to each other so as to minimize the shading effect. Bidder can propose suitable scheme during detailed engineering subject to engineering review and acceptance.

Cables used for inter-connecting SPV modules as well as Modules to SCB's shall conform to the requirements of EN 50618:2014 applicable for DC cable for photovoltaic system. The connectors used for interconnecting the modules and connectors used for connecting the strings and/or to the String combiner Box, i.e. field connectors to be mated shall be of same make and model otherwise they shall be tested for Inter-compatibility as per detailed Specification of Field Connectors given elsewhere in this specification).

These cables shall also meet the fire resistance requirement as per the above standard and shall be electron beam cured.

All cables except module cable used for (+) ve and (–)ve shall have distinct color identification.

In addition to manufacturer's identification on cables as per EN50618, following marking shall also be provided over outer sheath.

(a.) Cable size, voltage grade and code designation “PV”
(b.) Word 'HALOGAN FREE LOW SMOKE’
(c.) Sequential marking of length of the cable

The distance between two consecutive printing, identification or embossing shall not be more than 550 mm. The Printing shall be progressive, automatic, in line and marking shall be legible and indelible.

Type test, routine, acceptance tests requirements for these cables shall be as per EN50618:2014. All test charges shall be deemed to be included in the cable price. Sampling for acceptance tests will be as per suitable IEC.

A maximum of 8 Cables (4 Circuits) shall be laid in one HDPE Pipe for DC Cable from Module to string monitoring box (if applicable). The fill factor of the pipe should not be more than 40%.

However, in case of necessity to lay more than 8 cables (4 circuits) in one pipe, the same shall be allowed during detailed engineering and as per the derating factors recommended by the cable manufacturer. Fill factor criterion is still to be maintained.

Bidder to ensure that there is no gap and proper packing at the junction of two pipes, in which DC cable is laid, using proper method and accessories, like bell mouth.

Bidder can propose DC Cables (Interconnecting SPV Modules and from SPV Modules to SCB) with Nylon 12 sheath/other suitable material between Insulation and outer sheath of the DC Cable. Such cables can be laid without DWC/HDPE pipes. Such cable should be type tested. The proposal to accept such cable and such laying methodology shall be reviewed during detailed engineering.

9.2.2 DC CABLES (STRING COMBINER BOX TO INVERTER)

Cables used between SCBs and Inverters shall be of 3.3kV (E) grade. These Power cables shall have compacted Aluminium / copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), Armoured/ Unarmoured, FRLS PVC outer sheathed. These cables shall confirm to the requirements of the standards & codes specified in the relevant chapter.

For other details refer chapter –LT Cables

Bidder can propose DC Power Cables (SCB to Inverter) with armour of HDPE/other suitable material instead of Steel or Aluminium Armour. Such cable should be type tested. The proposal to accept such cable shall be reviewed during detailed engineering.

9.3 STRING COMBINER BOX

9.3.1 GENERAL

String Combiner Box (SCB) is used in multi-string photovoltaic systems to combine the individual strings electrically and connect them to the Inverters. It shall have protection devices to protect the PV modules from current/voltage surges. Nos. of input to each SCB shall be decided during detail engineering based on approved SLD and the temperature rise calculations.

Vendor to note that DC system 1500-Volt rating only is acceptable. Accordingly, component/assembly shall comply with 1500 V rating as applicable.

Voltage rating of the selected component shall be 1500V (Min.) as per system requirement during detail engineering. SCB offered for 1500V Application shall have already been type tested and in satisfactory operation in Solar plant with 1500 V DC system.

9.3.2 CODES AND STANDARDS

S NO.	CODES	DESCRIPTION
1	UL 94V	Fire Resistant/ flammability for Enclosure
2	UL 746C	UV Resistant for Enclosure
3	IEC 62262/EN 50102	Mechanical Impact Resistance for Enclosure
4	IEC 60529	Degrees of protection provided by enclosures (IP Code)
5	IEC 61643-12	Surge Protection
6	IEC 62208	Enclosure for low voltage Switchgear and control gear assemblies

Vendor shall submit the suitable Test Certificate/Report from accredited lab(s) indicating compliance of mentioned codes and standard if asked for the offered component or assembly.

9.3.3 GENERAL REQUIREMENT

SCB shall be equipped (but not limited to) with the following.

i. DC Disconnector /Breaker to disconnect the PV strings from the Inverter for maintenance purpose as per specification mentioned in this chapter.
ii. All component in the SCB shall be suitable for operation within temperature range of 0-65 Deg C.
iii. Fuse in each SCB input (both positive and negative) shall be provided to prevent the reverse short circuit current flow. However, in case of negative string fuse is not required as per recommendation of inverter manufacturer, string cable shall preferably be terminated with field connector with SCB.
iv. Surge Protection Devices for protection against surge currents and voltages as per specification given in separate clause. Other associated items like cable glands, lugs, vents and items required for the protection and completeness of the system shall be provided
v. The common collection bus bars should be made up of zinc/tin coated copper and shall be suitably sized to limit temperature rise within safe operating limits.
vi. Vendor shall ensure adequate clearance with suitable insulated separator between positive bus and negative bus if it is in same enclosure. Positive and

Negative section shall be orientated horizontally (Landscape orientation) on the either side of separator. Separate compartment for negative section and positive section for termination of positive and negative string input shall be preferred.

9.3.4 DC SURGE PROTECTION DEVICES (SPD) for PV Solar Application:

DC output SPD shall consist of three Metal Oxide Varistors (MOV) type surge arrestors which shall be connected from positive and negative bus to earth. The discharge capability of the SPD shall be at least 12.5kA at 8/20 micro second wave as per IEC 61643-12 and shall be rated for MCOV 1500 Volt DC. During fault and failure of MOV, the SPD shall safely disconnect the healthy system. SPD shall have thermal disconnector to interrupt the surge current arising from internal and external faults. In order to avoid the fire hazard due to possible DC arcing in the SPD due to operation of thermal disconnector, the SPD shall be able to extinguish the arc. SPD shall have local visual indication and potential free contact for remote indication.

9.3.5 STRING FUSES

In order to provide protection to all cables and modules, string fuses shall be provided with strings. String fuses shall be of PV category and dedicated to solar applications and conform to IEC 60269-6 or UL-2579 standards and fuse base shall comply with IEC 60269-1. String fuses should be so designed that it should protect the modules from reverse current overload. Fuses or Isolation Link shall be mounted in pull out type fuse holders. Fuse holders shall be suitable for DIN rail mounting. PCB mounted fuses are not acceptable. Fuse rating for single and combined input (limited to two) shall be calculated and finalized as per the current rating (Isc) of the PV module installed and the same be finalized during detailed engineering which shall be suitable for 1500 Volt for crystalline module.. For Thin film modules, fuse rating shall be decided during detail engineering. In case of negative grounded system, requirement of string fuses as well as inverter input fuses on negative side shall be decided based on the recommendation of Inverter (PCU) manufacturer. There should be minimum 10 mm gap between two fuses (fuse holders).

9.3.6 SCB ENCLOSURE AND ASSEMBLY

SCB shall satisfy the following requirement.

i. The enclosure shall be made of UV Protected, Halogen Free, and Fire-retardant GRP/FRP/Polycarbonate material with self-extinguishing property.
ii. Degree of protection for enclosure shall be at least IP 65. All the part shall be corrosion resistant and enclosure surface shall be free from crazing, blistering, wrinkling, color blots/striations. There should not be any mending or repair of surface.
iii. The mechanical impact resistance of enclosure shall be IK 07 or better.
iv. The size of the enclosure and general arrangement of the component shall be designed in such a way that the average temperature of enclosure shall not exceed 62 degree C and operating temperature of the components used in the enclosure shall not exceed 72 deg C or OEM recommended temperature limit at ambient temperature of 50 deg C for rated load conditions along with spare. The components mounted inside the SCB shall have higher temperature withstand capability and operation/performance of should not be affected due to derating by temperature.
v. Complete assembled SCB shall be subject to heat run type test to be witnessed by owner after manufacturing. The heat run test to be carried out at 1.25 times the rated current i.e. 1.25 x (Imp of PV Modules) x (no. of string inputs + spare). In case it is found that the temperature rise is beyond the acceptable limits, bidder shall redesign the assembly and perform the test free of cost to verify that temperature rise is within acceptable limit.
vi. In each SCB 5 % spare terminals along with cable glands and fuse rounded off to next higher integer shall be provided to connect the PV strings.
vii. All terminals blocks shall be rated for min 1000V/1500 V and rated continuously to carry maximum expected current.
viii. SCB shall be mounted under the PV module or under proper shed with minimum 150mm extension at all sides of SCB for protection from direct radiation. Design and dimensions of SCB structure must be such that minimum 400 mm (bending of DC cable also to be considered) of ground clearance is available below SCB at site for repair and maintenance. All the erection hardware and mounting accessories shall be galvanized steel.
ix. All internal wiring shall be carried out with stranded copper wires with voltage rating mentioned elsewhere in the specification. All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to component terminals and terminal blocks. Wire terminations shall be made with solder less crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations.

Engraved core identification plastic ferrules marked to correspond with the wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on wires and shall not fall off when the wire is disconnected from terminal blocks.

x. If metallic hinge is being used with enclosure cover, it shall be made of SS 304 and shall be rust proof. Enclosure shall be provided with captive screws so that it screw don't fall off when cover is opened. Screw shall be made of corrosion free material. Suitable non-conducting protection cover shall be provided for any metallic hinge/screw/fastener to avoid contact with live part of the assembly.

xi. Mounting plate inside the SCB for mounting/fixing of devices shall be made of FRP/GRP or equivalent non-conducting material.

xii. Offered enclosure shall have adequate space to fix one String Monitoring card, One Modbus SPD and One DC-DC converter for internal power supply with suitable terminal block for retrofitting of enclosure to convert the offered combiner box as String Monitoring Box in future by TPCLEFL. Vendor shall submit a sample Internal GA drawing with aforementioned components for future use of TPCLEFL in addition to the drawing/document(s) for inspection and dispatch of offered assembly for TPCEFL approval.

9.3.7 DC On-load Isolator

Solar PV On-load Isolator shall be suitable for 1500Vdc operational voltage having minimum Insulation voltage of 1500 V dc, in true 2 pole or 3 pole construction with 500Vdc per pole breaking. Any multipolar device achieving this configuration with shorting link (with less than 500Vdc per pole), will not be acceptable. The Isolators shall be type tested to carry the nominal current at rated Voltage till ambient Temperature of 60 Deg C without any de-ration, inside the String Junction box. The Switching part shall necessarily contain reinforced break with an integrated magnetic arc-extinguishing system for the PV arc. The PV isolator need to positive break indication given through a position indication window. The PV Isolator terminals need to be silver plated, and shall comply with IEC 60947-3 and tested for PV application. These shall withstand any PV current and should have no critical current.

9.3.8 TYPE TEST

Vendor shall submit the following Type Test/ Product Certification from any National/International accredited lab for approval.

a. Temperature rise test on complete assembled Box as per acceptable limit mentioned in relevant clause.

b. Type test for enclosure as per code and standard mentioned in relevant clause.
c. Thermal ageing at 70 Deg C for 96 hours as per IEC 60068-2
d. HV Test

9.3.9 DC plug-in connectors for field cabling

GENERAL REQUIREMENT

Field connectors are electrical connectors/coupler used for connecting solar panels and also strings of panels to String combiners box. Cable connector to be used for connecting SPV modules and String combiner boxes shall be in accordance with IEC 62852: 2014.

Connector shall be of plug and socket design to be plugged together by hand but can be separated again using a tool only. Contractor shall ensure that field connectors to be mated shall always be of same make and model or shall be tested Inter-compatible as per IEC 62852: 2014 for offered make(s).

Mating of connectors of different makes/model shall not be acceptable if not tested for inter-compatibility by any accredited lab.

Bidder can propose Y-connector type DC Field Connector for paralleling two DC strings from PV Module to SCB. However, bidder to provide suitably sized fuse in positive side of Y-connector.

TECHNICAL REQUIREMENTS

Rated Current, IEC (85°C)	30 A (4 mm^2, 6 mm^2), 40 A (10 mm^2)
Rated Voltage	Min 1500 Volts
Connector Design	Snap-In locking Type
Protection Degree	IP68 (Mated)
Ambient Temperature	(-) 40^0 C to (+) 85^0 C
Protection/Safety Class	Class II
Contact material	Cu
Contact surface material	Silver/Tin
Contact resistance for plug connecter	$\leq$ 0.5 milli-ohms
Stripping length	10 mm
Inflammability class	UL 94-V0

Insulating Material	PPE / PPO/Polyamide
Pollution degree	3
Certification	UL/TUV/CSA/EAC or Equivalent

TYPE TEST FOR DC plug-in connectors

a. Protection Degree (IP)
b. Operating Temperature
c. Inflammability
d. Pollution Degree
e. Voltage Withstand (Rated Voltage/Test Voltage)
f. Salt mist, cyclic (sodium chloride solution) as per IEC 60068-2-52
g. Product Certification

9.4 POWER CONDITIONING UNIT

9.4.1 Power Conditioning Unit

The Power Conditioning Unit (PCU) is Solar Inverter designed to convert solar PV DC power to 3-phase AC power and fed into utility grid. The PCU shall consist of solid-state electronic switch along with all associated control & protection, filtering, measuring instruments and data logging devices. Power conditioning unit shall be capable of capturing high resolution data (less than or equal to 10ms accuracy) for at least 10 seconds period during disturbances. The PCU shall have suitable maximum power point tracker (MPPT) for operating the input PV Array at its maximum power point. The PCU should have GRID forming capability and shall remain connected and stabilize the voltage & frequency of the GRID during GRID Disturbance.

9.4.2 CODES AND STANDARDS

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

IEC-61683	Energy efficiency requirements
IEC 61000	Emission/ Immunity requirement
IEEE 519	Recommended practices and requirements for harmonic control in electrical power systems.
IEC 60068	Environmental testing
IEC 62116	Testing procedure—Islanding prevention measures for power conditioners used in grid-connected photovoltaic (PV) power generation systems
IEC 62109-1 & 2	Safety of power converters for use in photovoltaic power systems.

EN 50530	Overall efficiency of grid connected photovoltaic inverters.
IEEE 1547/IEC 61727/ BDEW/IEEE 2800	Standard for interfacing solar PV plant with utility grid.
IEC 60529	Ingress protection test

9.4.3 GENERAL REQUIREMENTS

PCU shall meet the following technical parameter.

1.	Maximum Input voltage DC	1500V
2.	Nominal output voltage frequency	50Hz
3.	Continuous operating frequency range	47.5 Hz to 52 Hz
4.	AC Voltage Range	± 10% of rated AC voltage
5.	European efficiency	Minimum 97% (as per IEC 61683)
6.	Number of MPPT	Single MPPT or Multi-MPPT
7.	Surge Protection Device (SPD)	Type-I & II DC side
		Type-II AC side
8.	Operating power factor range	0.8 Lead to 0.8 Lag (adjustable)
9.	Night SVG (Q at Night)	Required.
10.	Current THD value	< 3% at nominal power
11.	DC Injection	<0.5 % at rated current
12.	Operating ambient temperature	0 to 60 ° C
13.	Humidity	95 % non-condensing
14.	Maximum Noise level	75 dBA (for indoor application)
15.	Flicker	As per EFL regulation
16.	Remote start and stop facility from SCADA	Required.
17.	Active power limit control, reactive power, and power factor control features.	Required. Possible both from PPC and SCADA.
18.	PCU designed DC fault current level	Maximum short circuit current of PV array connected to PCU and duration continuous.

19.	PCU designed AC fault current level	Maximum short circuit current of LV side of Inverter Duty transformer and duration one sec.
20.	(i) AC & DC overcurrent protection. (ii) Synchronization loss protection. (iii) Over temperature protection. (iv)DC & AC under and over voltage protection. (v) Under & over frequency protection. (vi) Cooling system failure protection (vii) PV array ground fault monitoring & detection (viii) PV array insulation monitoring (ix) LVRT protection (x) Anti-islanding protection (xi) Grid monitoring (xii) GRID Forming & Black Start Capability	Required.

1. The PCU shall comply with the EFL regulations with all latest amendments.
2. The PCU shall be capable of supplying reactive power as per grid requirement during solar and non-solar hours. PCU shall have Static Var Generation (SVG) function.
3. The PCU shall have protection against any sustained fault in the feeder line and against lightning discharge in the feeder line.
4. The Contractor shall ensure by carrying out all necessary studies that the PCU will not excite any resonant conditions in the system that may result in the islanded operation of PV plant and loss of generation. In case there is excitation of any resonant condition in the system during PV plant operation that may result in the islanding/tripping of the PV plant and affect the power transfer, it shall be the responsibility of contractor to rectify the design and carryout required modification in the equipment of his supply.
5. The PCU must be self-managing and stable in operation.
6. In case of grid failure, the PCU shall be re-synchronized with grid after revival of power supply. Bidder to furnish the time taken by PCU to be re-synchronized

after restoration of grid supply during detailed engineering. PCU shall be capable to synchronize with BESS PCS during blackstart and shall have required feature.

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

8. PCU shall have necessary limiters in build in the controller so as to ensure safe operation of the PCU within the designed operational parameters.

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

10. PCU shall be provided with Mobile user interface facility for monitoring of inverter by plant O&M personal for better O&M and highest yield from the PV plant. In case PCU does not have this facility, then Bidder can provide the same facility through plant SCADA system.

11. PCU shall have AC and DC side monitoring capability and reporting to SCADA system (measured analog and digital value measured within PCU). Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.

12. All-important alarm and trip signals shall be configured in the PCU and their corresponding Modbus address shall be provided for SCADA configuration. Signal shall necessarily be included such as LVRT in action and trip operated, HVRT trip, islanding protection operated, over current operated, Inverter cabinet temperature high alarm and all other important signals. Details shall be finalized during details engineering stage.

13. DC Overloading: - Maximum PCU DC overload loading shall be limited to its design PV Array Power to PCU nominal AC power ratio. Bidder needs to submit all the relevant technical document/test report from PCU manufacturer (OEM) during details engineering stage in support of declared PCU design DC overloading capacity.

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

15. OPERATING MODES OF PCU

a. **Low Power Mode:-** The PCU shall be able to wake-up automatically when PV array open circuit voltage value is equal/more than preset value in the PCU program. Once its start generation the PCU shall automatically enter maximum power mode.

b. **Maximum Power Point Tracking (MPPT):-** In order to maximize the energy collection from solar PV array, the PCU shall have inbuilt MPPT controller and same shall be able operate the PV array at its maximum power point by adjusting output voltage of PV array system according to atmospheric condition. PCU MPPT controller shall ensure that it operate the PV array system at its global maximum power point under all operating conditions of PV array including cloudy atmospheric condition.

c. **Sleep Mode** :- PCU shall automatically go into sleep mode when the output voltage of PV array and/or output power of the inverter falls below a specified limit. During sleep mode the inverter shall disconnect from grid. Inverter shall continuously monitor the output of the PV array and automatically start when the DC voltage rises above a pre-defined level.

   The above clause is applicable for unity power factor operation/no reactive power support to grid. In case reactive power is required to be supplied to grid, in that case the PCU shall remain connected to grid and supply reactive power as per grid requirement. Inverter shall continuously monitor the output of the PV array and automatically start active power generation when the DC voltage rises above a pre-defined level.

d. **Standby Mode:-** In standby mode the PCU DC & AC contactor are open, inverter is powered on condition and waiting for start command.

16. In case auxiliary supply of PCU is met internally, then it should have sufficient power backup to meet the LVRT requirement.

17. Bidder to submit third-party verified OND files of the inverter during detail engineering.

9.4.4 CENTRAL INVERTER

1. PCU must have provision to be isolated from grid through Air Circuit Breaker/MCCB. The ACB/MCCB as required can be provided as a part of PCU/its Modules or separately based on standard design and configuration of PCU manufacturer. The ACB and MCCB shall be able to withstand the maximum fault current for minimum one sec duration. ACB/MCCB shall be able to isolate PCU from AC grid under all fault current condition. Any alternate provision other than ACB/MCCB which is recommended by OEM and meeting the requirement, shall be considered on case-to-case basis during detailed engineering stage.

2. Suitable rated fuse shall be provided (at inverter end) in incoming DC cable from each string combiner box (SCB). One set spare terminal with fuse (as applicable) and holder shall be provided for the future use. In addition, the PCU shall have suitable rated DC motorized isolator/MCCB or contactor for isolation of PV array from inverter.

3. String Monitoring facility:- PCU shall be provided with current monitoring transducer at incoming DC cables from each string combiner box (SCB) for PV array zone monitoring purpose. The current transducers used for this purpose shall have accuracy of 1.0 class or better.

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

5. PCU shall have suitable communication card (Modbus TCP/IP) for networking and SCADA integration and same shall support dual master communication. PCU shall include all important measured & internal calculated analog values and alarm & trip signals for remote monitoring, storing and report generation purpose in SCADA system. Details list of above such parameters

shall be provided along with their Modbus address during detail engineering stage.

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

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

8. The Inverter shall have suitable arrangement for negative grounding of solar PV array system and the ground current shall be limited to safe limit. Ground current shall be measured continuously, and alarm shall be generated in case ground current reaches to predefined set value. Inverter shall trip in case ground current more than safe operating limit.

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

10. INDOOR CENTRL INVERTER

a) The PCU enclosure protection class shall be IP 55 or better protection.

b) COOLING AND VENTILATION: -

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

Ventilation shall be designed in such a way that the temperature rise of the inverter rooms does not exceed the maximum designed temperature of Inverters and other auxiliary equipment's placed inside the inverter room. Accordingly, the air velocity

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

9.4.5 TYPE TESTING

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

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

9.5 BATTERY AND BATTERY MANAGEMENT SYSTEM

9.5.1 CODES AND STANDARDS

The BESS shall conform to all applicable IEC and UL standards. Where an applicable IEC/UL standard is not available, any applicable international standard shall be referred to as best practice.

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

Standard	Requirement / Description	Applicability / Remarks
IEC 62485-2	Safety requirements for secondary batteries and battery installations to address safety aspects associated with erection, use, inspection, maintenance, and disposal. Applicable for Lead Acid and NiCd/NiMH batteries.	Applicable only for Lead Acid and NiCd/NiMH batteries.

IEC 61850 / DNP3	Communications networks and management systems for BESS control system communication.	Required for BESS control system communication.
UL 1973 (Battery) or IEC 62619 (Battery) + IEC 63056 (Battery)	Batteries for use in stationary, vehicle auxiliary power and light electric rail (LER) applications / Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries for use in industrial applications.	Either UL 1973 or (IEC 62619 + IEC 63056) required at battery level.
UL 1642 or UL 1973, Appendix E (Cell) or IEC 62619 (Cell) + IEC 63056 (Cell)	Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries for use in industrial applications.	Required at cell level.
IEC 62933-2-1	Electrical Energy Storage (EES) Systems - Part 2-1: Unit Parameters and Testing Methods - General Specification.	Tests for Class-B application: 1. Duty Cycle Round Trip Efficiency Test 2. Equipment and Basic Function Test 3. Available Energy Test 4. Insulation Test
IEC 62281 / UN 38.3	Safety of primary and secondary lithium cells and batteries during transport. Applicable for storage systems using Lithium-Ion chemistries.	Required for both battery and cell.
UL 9540 or IEC TS 62933-5-1 + IEC 62933-5-2	Electrical Energy Storage (EES) Systems - Part 5-1: Safety considerations for grid-integrated EES systems - General specification / Standard for Energy Storage Systems and Equipment.	Either UL 9540 or (IEC 62933-5-1 + IEC 62933-5-2) required at BESS system level.

IEC 61427-2	Secondary cells and batteries for renewable energy storage for on-grid applications - General requirements and methods of test.	Required for cells and battery modules.
UL 9540A	Standard for Thermal Runaway Testing.	Required at BESS system level.

9.5.2 Battery Subsystem Design Requirements: -

Electrochemical Cells

Only cells that are commercially available or for which suitable (not necessarily identical) replacement cells can be supplied on short notice will be allowed. For both premature cell failures and end-of-battery-life replacement, the Contractor shall guarantee cell availability and the length of down time (hours or days) required to replace cells. The cells may be supplied as separate, individual units or as group of cells combined into modules. The cells shall meet the seismic requirements for the planned location of the BESS. Cell and module design shall accommodate the anticipated vibrations and shocks associated with the transportation of the BESS and shall resist deterioration due to vibrations resulting from the same. Associated hardware and paraphernalia should also be able to withstand the rigors of transportation. The transport plan shall be shared with the Employer and approved prior to dispatch.

Labelling of cells or unit batteries shall include manufacturer's name, cell type, nameplate rating, and year of manufacture etc (to be decided during detailed engineering), in fully legible characters. All cells shall be traceable to the point of origin for purpose of addressing safety issues.

Electrochemical Storage System

1. The storage system may consist of one or more-unit batteries. If the storage system consists of more than one unit battery, these may be electrically interconnected in any desirable series and parallel configuration to achieve the overall system storage and power rating requirements.

   The DC voltage of battery system shall be selected by the Bidder to suit the PCS and battery efficient and safe operational requirement.

2. Each electrically series-connected string of unit batteries shall include a means of disconnecting the string from the rest of the system and of providing over-current protection (during a fault). This protection shall be coordinated with the PCS capabilities and battery string protection and shall tak e into account switching or other transients and the inductance / resistance (L/R) ratio at the relevant areas of the dc system. The means of disconnect shall provide for a physical interruption of the string electrical circuit, which shall be visible to anyone servicing the individual unit batteries in the string.

3. If the disconnect means consists of removal of a unit battery, the storage system shall be designed to allow maintenance personnel to determine that there is no current flowing in the string and provisions to ensure that the PCS is off before the unit battery is removed. Procedures for maintenance and/or field replacement of unit batteries shall neither require nor recommend removal of the unit battery without first ensuring that no current is flowing in the string circuit.

4. Over-current protection, whether on the ac or dc side, in paralleled unit battery strings shall be sized and coordinated so that currents from other strings do not contribute to a fault in any unit battery string.

5. Where appropriate, dc wiring shall be braced for available fault currents. Protection shall include a dc breaker, fuse, or other current-limiting device on the battery bus. This protection shall be coordinated with the PCS capabilities and battery string protection. The Contractor shall produce a fault analysis and protection coordination study for the battery dc subsystem during final design. The Employer reserves the right to withhold permission to ship the BESS until the fault analysis has been satisfactorily completed.

6. Cells, wiring, switch gear, and all dc electrical components shall be insulated for the maximum expected voltages plus a suitable factor of safety as per standard/subject to approval during detail engineering. Cell and module terminals and interconnects shall have adequate current-carrying capacity. The polarities of cell and module terminal posts shall be embossed on the cover at the terminal.

7. The battery system shall include a system to detect and alarm excessive ground leakage current levels. Ground fault detection shall be enabled for the container or, if more than one electrical series string is installed in the container, for each series string. The detection/trip level shall be field adjustable. The Contractor shall have overall responsibility for the safety of the electrical design and installation of the battery, as well as all aspects of the BESS.

8. The battery system shall include a monitoring/alarm system and/or prescribed maintenance procedures to detect abnormal unit battery conditions and notify proper personnel of their occurrence.

9. Abnormal conditions shall include but not be limited to (1) weak unit batteries that could reasonably be expected to fail to provide rated capacity upon full discharge, (2) high-resistance or open-unit batteries, (3) high-resistance or open external unit battery connections, (4) unit batteries with temperatures exceeding operating thresholds, and (5) internally shorted unit batteries. Unit battery monitoring, whether automatic or manual, should be specified to alert the proper personnel in a timely manner that an abnormal unit battery condition exists or may exist. All alarms shall be part of the control system and shall include remote display or annunciation capability.

10. The unit batteries shall be racked or shall be housed in stackable modules. The unit batteries or cells shall be arranged and installed to permit easy access for equipment and personnel. The moveable units shall be arranged and installed to permit easy access for equipment and personnel to carry out unit removal and replacement activities. For all systems, it shall be possible to remove and replace a prematurely failed unit battery or cell (as appropriate), when system performance specifications cannot be met. The lengths and widths of all aisles and spaces into which personnel may enter in the field for operations and/or routine or unscheduled maintenance purposes, as well as egress routes from these aisles and spaces, shall conform to applicable codes and standards. All racks and metallic conductive members of stackable modules shall be grounded to earth. Racks shall meet the seismic load and road vibration requirements and shall include means to restrain cell movement during seismic events and transport. The Contractor shall furnish analyses and/or other data that show that the rack and cell designs are designed to meet all potential seismic and transport vibration requirements.

11. Preferably, Provision shall be made for future Augmentation/Replacement by keeping Spare Racks for accommodating Battery Stack Modules capacity.

12. The design of all modules and racks shall specifically account for the anticipated vibrations and shocks associated with the transportation of the BESS.

13. Cell/Battery Auxiliary Systems:

- The cells and battery system shall be supplied with all required and/or recommended accessories. This includes inter-cell connectors & monitoring devices for cell temperature and cell voltage, if required.

9.5.3 BATTERY MANAGEMENT SYSTEM (BMS):

The BMS shall be designed to provide automatic, unattended operation of the battery storage system. BMS shall manage a rechargeable battery (cell or battery pack), including protecting the battery from operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it.

a) Battery storage shall discharge based on battery capacity and real-time load. The reference value shall be updated periodically depending upon the electrical parameter measurement. The charging shall be performed in constant current constant voltage (CCCV) mode. However, change of operating mode from CC to CV during charging shall be determined on the basis of Supplier recommendations and the battery type and technology offered.

b) The battery storage shall discharge on real time basis as per functional requirement. Battery SoC shall be monitored periodically to evaluate the remaining capacity at start of discharge operation and accordingly a constant rate of discharge will be defined. Further, an additional feature shall be provided to change/edit the discharge duration and rate of discharge whenever required.

c) BMS shall monitor battery system parameters such as string voltage & current, cumulative number of cycles and throughput along with DoD. It shall automatically determine the State of Charge (SOC) and State of Health (SOH) of the battery individual cell/module.

d) It shall also monitor utility side parameters such as voltage, charge/discharge current and protection system readings/status.

e) BMS shall automatically control the charging state of each module based on monitoring of parameters and power/energy requirements. It should charge the module in float/boost mode and/or Constant Current Constant Voltage (CC-CV) mode as per requirements of battery sub system. It shall also be designed to protect the battery cells/module/string from out of tolerance and

unsafe operating conditions under any eventuality and mitigate fire risk. Further, it should regulate the voltage to limit the temperature rise in the cell.

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

g) Monitoring and storing the battery's parameters and communicating the same to SCADA/EMS.

h) Alarm and fault generation and communicating the same to SCADA/EMS

i) Isolating the battery in cases of any emergency.

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

9.5.4 TYPE TESTING:

During detailed engineering, the contractor shall submit all the type test reports carried out within last ten years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on the equipmen t similar to those proposed to be supplied under this contract and the test(s) should have been either should have been witnessed by a client or conducted at an independent laboratory by one of the ILAC member signatory accredited laboratories. In case of module types/ BESS/equipment for which such Test facilities may not exist in Fiji at present, test certificates from reputed ILAC Member body accredited Labs abroad will be acceptable.

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

9.6 POWER CONVERSION SYSTEM

9.6.1 Power Conversion System

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

9.6.2 CODES AND STANDARDS

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

IEC-61683 Ed.1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency requirements
IEC 61000-6-2 Ed.2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-2 Ed.2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEEE 519-2022	Recommended practices and requirements for harmonic control in electrical power systems.
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat

IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h+ 12 h cycle)
IEC 62116 Ed.2	Testing procedure—Islanding prevention measures for power conditioners used in grid- connected photovoltaic (PV) power generation systems
IEC 62477-1	Safety Requirements for power electronic converter systems and equipment-Part-1: General
IEC 62477-2	Safety Requirements for power electronic converter systems and equipment-Part-2: Power electronic converters from 1000Vac or 1500V DC up to 36kV AC or 54kV DC
IEEE 1547/IEC 61727/ BDEW (as applicable)	Standard for interfacing solar PV plant with utility grid.
IEC 60529	Ingress protection test

9.6.3 GENERAL REQUIREMENTS

PCS shall meet the following technical parameter

1.	**Nominal output voltage frequency**	**50Hz**
2.	Continuous operating frequency range	**47.5 Hz to 52.5 Hz**
3.	AC Voltage Range	**± 10% of rated AC voltage**
4.	Euro efficiency	**Minimum 97% (as per IEC 61683)**
5.	Surge Protection Device (SPD)	**Type-I & II DC side**
		Type-II AC side

6.		
7.	Operating power factor range	**0.8 Lead to 0.8 Lag (minimum)**
8.	SVG /Four Quadrant Operation	**Required.**
9	Current harmonics	**IEEE 519**
10	Current THD value	**< 3% at nominal power**
11	DC Injection	**<0.5 % at rated current**
12	Operating ambient temperature	**0 to 60 ° C**
13	Humidity	**95 % non-condensing**
14	Maximum Noise level	**75 dBA (for indoor application)**
15	Flicker	**As per EFL regulation**
16	Remote start and stop facility from SCADA/EMS	**Required.**
17	Active power limit control, reactive power, and power factor control features.	**Required. Possible both from PPC and/or EMS SCADA.**
18	PCS designed DC fault current level	**Maximum short circuit current of Battery system connected to PCS and suitable duration.**
19	PCS designed AC fault current level	**Maximum short circuit current of LV side of PCS Duty transformer and duration one sec.**
20	(i) **AC & DC overcurrent protection.** (ii) **Synchronization loss protection.** (iii) **Over temperature protection.** (iv) **DC & AC under and over voltage protection.** (v) **Under & over frequency protection.** (vi) **Cooling system failure protection** (vii) **Battery array ground fault monitoring & detection (if applicable)** (viii) **Battery system insulation monitoring (if applicable)** (ix) **LVRT protection** (x) **Anti-islanding protection** (xi) **Grid monitoring**	**Required.**

1. The PCS shall comply with the FIJI ELECTRICITY ACT 2017 and the EFL Grid Code with all latest amendments.

2. The PCS shall be capable of supplying reactive power as per grid requirement. PCS shall have Static Var Generation (SVG) function

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

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

5. The Contractor shall ensure by carrying out all necessary studies that the PCS will not excite any resonant conditions in the system that may result in the islanded operation of BESS plant and loss of generation. In case there is excitation of any resonant condition in the system during BESS plant operation that may result in the islanding/tripping of the BESS plant and affect the power transfer, it shall be the responsibility of contractor to rectify the design and carryout required modification in the equipment of his supply.

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

7. In case of grid failure, the PCU shall be re-synchronized with grid after revival of power supply. Bidder to furnish the time taken by PCU to be re-synchronized after restoration of grid supply during detailed engineering.

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

9. PCS shall have necessary limiters in build in the controller so as to ensure safe operation of the PCS within the designed operational parameters.

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

11. PCS shall have AC and DC side monitoring capability and reporting to SCADA/EMS system (measured analog and digital value measured within PCS).Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.

12. All-important alarm and trip signals shall be configured in the PCS and their corresponding modbus address shall be provided for SCADA/EMS configuration. Signal shall necessarily be included such as LVRT in action and trip operated, HVRT trip, islanding protection operated, over current operated, PCS cabinet temperature high alarm and all other important signals. Details shall be finalized during details engineering stage.

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

14. In case auxiliary supply of PCS is met internally, then it should have sufficient power backup to meet the LVRT requirement.

15. Bidder to submit third-party verified OND files of the PCS during detail engineering.

16. Bidder shall provide only central PCU

9.6.4 CENTRAL PCS:-

1. PCS must have provision to be isolated from grid through Air Circuit Break er/MCCB. The ACB/MCCB as required can be provided as a part of PCS/its Modules or separately based on standard design and configuration of PCS

manufacturer. The ACB and MCCB shall be able to withstand the maximum fault current for minimum one sec duration. ACB/MCCB shall be able to isolate PCS from AC grid under all fault current condition. Any alternate provision other than ACB/MCCB which is recommended by OEM and meeting the requirement, shall be considered on case-to-case basis during detailed engineering stage.

2. PCS shall have suitable rated DC isolator/contactor for isolation of DC Battery system from PCS. Suitable rated fuse shall be provided (at PCS end) in incoming DC cable from battery system. One set spare terminals with fuse/link (as applicable) and holder shall be provided for the future use.

3. String Monitoring facility:- PCS shall be provided with current monitoring transducer at incoming DC cables from each battery array. The current transducers used for this purpose shall have accuracy of 1.0 class or better

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

5. Local Display unit for viewing important parameters configuration and troubleshooting purpose shall be provided. Alternative arrangement through local mounted/ handheld device with suitable communication protocol can be considered subject to review and approval during detailed engineering.

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

7. In case of modular design of PCS is offered, the Contractor shall ensure that no abnormal interaction shall take place among the various PCS modules during any grid operating condition which may result in outages. The PCS controller offered by the Contactor shall be such as to ensure stability, reliability, and a good

dynamic performance. The Bidder shall indicate the control scheme adopted for modular PCS and its merits and the test which will check its performance.

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

9. PCS shall have emergency stop push button for tripping of PCS with complete DC & AC electric isolation.

10. Automatic 'sleep' mode shall be provided so that unnecessary losses are

11. Indoor PCS:-

- The PCS enclosure protection class shall IP 55 or better protection. Bidder to submit temperature endurance test report of complete assembly during detail engineering stage.
- Structural steel and paints for shed shall be as per ISO 12944-5.
- containerized solution platform shall be raised Min1250 mm from NGL. Cable bending radius and other relevant factors to be considered during platform design. This shall be reviewed during detailed engineering.

Type Testing

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

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

10. AC SYSTEMS

10.1 LT SWITCHGEAR

10.1.1 CODES AND STANDARDS

The design, materials, and method of LT switchgear shall conform to the applicable IEC standard or AS/NZS. All equipment shall be installed and all work shall be carried out in accordance with relevant IEC standards. Where an applicable IEC standard is not available, any applicable international standard shall be referred to as best practice. All standards, specifications and codes of practice shall be the latest editions including all applicable official amendments and revisions.

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

Standard	Details
IEC 60947/	Low-voltage switchgear and control gear
IEC61869	Current Transformers
IEC 60364-5-54, IEC 60364-5 /IEEE 80	Code of practice for earthing.
IEC 61936-1 /IEC 62271	Code of practice for installation and maintenance of Switchgear
IEC 61869-3	Voltage Transformers
IEC 60529/ ISO 12944	Code of practice for climate proofing of electrical equipment.
IEC 60255	Electrical relays for power system protection.
IEC 60269	HRC Cartridge fuses

IEC 61439/IEC62271	Code of practice for selection, installation and maintenance of switchgear and control gear.
IEC 60255	Electrical Relays
IEC 61641	Enclosed low-voltage switchgear and control gear assemblies – Guide for testing under conditions of arcing due to internal fault

10.1.2 TECHNICAL PARAMETERS

A. POWER SUPPLY (AC SYSTEM)		
(i)	Voltage	415V ± 10%, 3 Phase, 4 wire, Neutral Solidly Earthed
(ii)	Frequency	50 Hz +/- 5%
(iii)	Minimum system fault level	As per system fault current (for 1 sec)
(iv)	Short time rating for bus bars, ckt. breakers, current transformers and swgr. Assembly.	As per system fault current (for 1 sec)
(v)	Maximum ambient air Temperature	50 deg. C
BUS BARS		
(vi)	Continuous current rating at 50°C ambient:	As Per Requirement

B. MCCB		
(i)	Rated voltage	415V
(ii)	Rated Insulation Level	690V
(iii)	Rated ultimate and service SC breaking capacity (As per system requirement)	As per system fault current (for 1 sec)
(iv)	Rated making capacity	2.1 times of System fault current
(v)	Utilization category	A
C. DIGITAL MFM		
(i)	Accuracy class	0.5
(ii)	MFM shall be provided at LT incomer feeder. MFM shall have suitable communication port for integration with SCADA system.	
D. CURRENT TRANSFORMERS		
(i)	Type	Cast Resin Bar Primary
(ii)	Voltage class and frequency	650V, 50HZ
(iii)	CT Secondary Current	1 A
(iv)	Class of insulation	E or better
	Accuracy class & burden	

	a) For Protection	5P20, 5VA
	b) For Metering	Class 1.0, 5VA (min)
(vi)	Instrument Security Factor for metering CT	5
E. VOLTAGE TRANSFORMERS		
(i)	Type	Cast Resin
(ii)	Voltage Ratio	415 / 110V for line PT 415/√3 / 110/√3V for Bus PT
(iii)	Method of Construction	Vee Vee
(iv)	Accuracy Class	0.5
(v)	Rated Voltage factor	1.1 continuous, 1.5 for 30 sec.
(vi)	Class of insulation	E or better
(vii)	One minute power frequency withstand voltage	2.5 KV
F. HRC FUSES		
(i)	Voltage Class	650 Volts
(ii)	Rupturing capacity	80kA (RMS) for AC circuits

G. CONTACTORS		
(i)	Type	Air break electro magnetic
(ii)	Utilising Category	AC3 of IEC 60947 for non reversible AC4 of IEC 60947 for reversible drives
H. SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS		
(i)	Colour finish	
	Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers) The paint thickness shall not be less than 50 microns
	Cable entry	
(ii)	Power Cables	Bottom
	Control Cables	Bottom

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

10.1.3 DETAILS OF DISTRIBUTION BOARDS

Applicable for Auxiliary Power Supply system and distribution board of rating up to & including 400A.

- Switchboards in CMCS , Inverter Room & BESS area shall be of metal enclosed, indoor, floor-mounted, free-standing type. Distribution boards of small size can be of wall/channel mounted type. For inverter & BESS stations, if outdoor

distribution boards/LT pooling switchgear is proposed, the same shall be of suitable IP class and shall be kept under shed.

- All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold-rolled sheet steel and 4.0 mm for non-magnetic material.

- All panel edges and cover / door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge/ bend by the weight of maintenance personnel working on it.

- The switchboards shall be of bolted design. The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cut outs shall be true in shape and devoid of sharp edges.

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

- All switchboards shall be of uniform height not exceeding 2450 mm.

- Switchboards shall be supplied with base frames made of structural steel sections, along with all necessary mounting hardware required for welding down the base frame to the foundation / steel insert plates.

- All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. Replacement /Maintenance of individual equipment/ component shall be possible without switching off or isolating the other equipment/components.

- Each switchboard shall be provided with undrilled, removable type gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall be provided with gasket to ensure enclosure protection.

- The minimum clearance in air between phases and between phases and earth for the entire busbars shall be 25mm. For all other components, the clearance

between "two live parts", "a live part and an earthed part", shall be at least ten (10) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for busbars the clearances specified above should be maintained even when the busbars are sleeved or insulated. All connections from the busbars up to switch / fuses/MCCB shall be fully insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits. All busbars and jumper connections shall be of high conductivity aluminium alloy / copper of adequate size.

- All switchboards shall be provided with three phase and neutral busbars. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.

- The cross-section of the busbars shall be uniform throughout the length of switchboard section and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents. Neutral busbar short circuit strength shall be same as main busbars.

- All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet moulded compound or equivalent type polyester fiber glass moulded insulator. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided, anti-tracking barriers shall be provided between the supports. Insulator and barriers of inflammable material such as Hylam shall not be accepted. The busbar insulators shall be supported on the main structure.

- All busbar joints shall be provided with high tensile steel bolts, belleville / spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated busbar joints shall be thoroughly cleaned at the jointed locations and suitable contact grease shall be applied just before making a joint. All bolts shall be tightened by torque spanner to the recommended value. The overlap of the busbars at each joint surface shall be such that the length of overlap shall be equal to or greater than the width of the busbar. All copper to aluminium joints shall be provided with suitable bimetallic washers.

- All busbars shall be colour coded as per IEC 60445.

- Wherever the busbars are painted with black Matt paint, the same should be suitable for temperature encountered in the switchboard under normal operating conditions.

- The Bidder shall furnish calculations establishing the adequacy of bus bar sizes for specified current ratings.

- Panel space heaters shall be provided and the supply for this shall be tapped from incomer, before the isolating switch/circuit breaker. Incoming circuit to space-heater shall have an isolating switch, HRC fuse and neutral link of suitable rating. Panel illumination and plug-socket shall also be tapped from the space heater supply.

- A galvanized steel / Copper / Aluminium earth bus shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded / bolted to the framework of each panel and breaker earthing contact bar. Vertical earth bus shall be provided in each vertical section which shall in turn be bolted / welded to main horizontal earth bus.

- The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current to earth without exceeding the allowable temperature rise.

- All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosure framework and truck shall be maintained even after painting.

- All metallic cases of relays, instruments and other panel-mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. All the equipment mounted on the door shall be earthed through flexible wire/braids. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors, soldering is not acceptable. Looping of earth connections, which would result in loss of earth connections to other devices, when a device is removed, is not acceptable. However, looping of earth connections between equipment to provide alternative paths to earth bus is acceptable.

- VT and CT secondary neutral point earthing shall be at one place only, i.e. on the terminal block. Such earthing shall be made through links so that earthing of one

secondary circuit shall be removed without disturbing the earthing of other circuit.

- All hinged doors having potential carrying equipment mounted on it shall be earthed by flexible wire/ braid. For doors not having potential carrying equipment mounted on it, earth continuity through scraping hinges/ hinge pins of proven design may also acceptable. The Contractor shall establish earth continuity at site also.

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

- All auxiliary wiring shall be carried out with 650V grade, single core stranded copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5 mm2 (min.) for control circuit wiring and 2.5 mm2 (min) for CT and space heater circuits.

- Extra flexible wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the doors shall be properly sleeved or taped.

- All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminal blocks.

- All internal wiring terminations shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor or an equally secure method. Similar lugs shall also be provided at both ends of component-to-component wiring. Insulating sleeves shall be provided over the exposed parts of lugs to the extent possible. Screw-less (spring loaded) / cage clamp type terminal shall also be provided with lugs.

- Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IEC 60445. Red Ferrules should be provided on trip circuit wiring.

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

- All power cable terminals shall be of stud type and the power cable lugs shall be solderless crimping ring type. All lugs shall be insulated/ sleeved.
- All Switchgears, MCCs, Distribution Boards, Fuse boards, all feeders, local push-button stations etc. shall be provided with prominent, engraved identification plates.
- All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Inscription & lettering sizes shall be subject to Employer's approval.
- Caution name plate "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.
- The gaskets, wherever specified, shall be of good quality EPDM / neoprene with good ageing, compression and oil resistance characteristics suitable for panel applications.
- The bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature as per AS/NZ standards / specification. Continuous current rating at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.
- ON/OFF status and protection trip status of incomers and bus coupler (if applicable as per SLD) be provided for SCADA system.
- Suitable changeover and interlocking arrangement shall be provided for incomers and bus coupler (if applicable as per SLD).
- It shall be the responsibility of the contractor to fully coordinate the overload and short circuit breakers/fuses with the upstream and downstream circuit breakers / fuses, to provide satisfactory discrimination. Further the various equipment supplied shall meet the requirements of type ii class of co-ordination as per IEC 60254
- All sheet steel work shall be pretreated in tank. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "class-c"

as specified in ISO-10721. The phosphated surfaces shall be rinsed and passivated. After passivation, electrostatic powder coating shall be used. Powder should meet requirements of IEC 60502 (powder costing specification). Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless otherwise required by the employer. The paint thickness shall not be less than 50 microns.

10.1.4 MCCB

- MCCB shall be fixed type module, air break type, having trip free mechanism with quick make and quick break type contacts. MCCB shall have current limiting feature. MCCB of identical ratings shall be physically and electrically interchangeable. MCCB shall be provided with 1 NO and 1NC auxiliary contacts.

- MCCB shall have inbuilt front adjustable releases (overload & short circuit) and shall have adjustable earth fault protection unit also. The protection settings shall have suitable range to achieve the required time & current settings. LED indications shall also be provided for faults, MCCB status (on/off etc).

- MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit rating. Extended cable terminal arrangement for higher size cable may also be offered. ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB, such that the door can not be opened unless the MCCB is in OFF position. Means shall be provided for defeating this interlock at any time. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked. The MCCBs being offered shall have common/interchangeable accessories for all ratings like aux. switch, shunt trip, alarm switch etc. The MCCBs shall have the current discrimination up to full short circuit capacity and shall be selected as per manufacturer's discrimination table.

10.1.5 FUSES

- All fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC circuits shall be rated for 80kA rms (prospective) breaking capacity at 415V AC and for DC circuits, 20kA rms breaking capacity at 240V DC.

- Fuse shall have visible operation indicators. Insulating barriers shall be provided between individual power fuses.

- Fuse shall be mounted on insulated fuse carriers, which are mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type of bases. In such cases one set of insulated fuse pulling handles shall be supplied with each switchboard.

- The Neutral links shall be mounted on fuse carriers which shall be mounted on fuse bases.

10.1.6 CIRCUIT BREAKERS (If required)

- Circuit breakers shall be three pole, air break, horizontal draw out type, and shall have fault making and breaking capacities as specified in "Technical Parameters". The circuit breakers which meet specified parameters of continuous current rating and fault making / breaking capacity only after provision of cooling fans or special device shall not be acceptable.

- Circuit breakers along with its operating mechanism shall be provided with suitable arrangement for easy withdrawal. Suitable guides shall be provided to minimize misalignment of the breaker.

- There shall be "SERVICE", "TEST" and "FULLY WITHDRAWN" positions for the breakers. In "Test" position the circuit breaker shall be capable of being tested for operation without energising the power circuits i.e. the power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the "SERVICE", "TEST" or "FULLLY WITHDRAWN" position. Circuit Breaker rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition.

- Separate limit switches, each having required numbers of contacts shall be provided in both "SERVICE" and "TEST" position of the breaker. All contacts shall be rated for making, continuously carrying and breaking 10 Amp at 240 V AC and 1 Amp (Inductive) at 240 V DC respectively.

- Suitable mechanical indications shall be provided on all circuit breakers to show "OPEN", "CLOSE", "SERVICE ", "TEST" AND "SPRING CHARGED" positions.

- Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half a cycle of rated frequency.

- Movement of a circuit breaker between "SERVICE" and "TEST" position shall not be possible unless it is in open position. Attempted withdrawal of a closed circuit breaker shall preferably not trip the circuit breaker. In case the offered circuit breaker trips on attempted withdrawal as a standard interlock, it shall be ensured that sufficient contact exists between the fixed and drawout contact at the time of breaker trip so that no arcing takes place even with the breaker carrying its full rated current.

- Closing of a circuit breaker shall not be possible unless it is in "SERVICE" position, "TEST" position or in "FULLY WITHDRAWN" position.

- Circuit-breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the stationary isolated contacts when the breaker is withdrawn. It shall however be possible to open the shutters intentionally against pressure for testing purposes.

- Breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.

- Circuit breakers shall be provided with coded key / electrical interlocking devices, as per requirements.

- Circuit breaker shall be provided with anti-pumping feature and trip free feature, even if mechanical anti-pumping feature is provided.

- Mechanical tripping shall be possible by means of front mounted Red "trip" push-button. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.

- Complete shrouding / segregation shall be provided between incoming and outgoing bus links of breakers. In case of bus coupler breaker panels the busbar connection to and from the breaker terminals shall be segregated such that each connection can be approached and maintained independently with the other bus section live. Dummy panels if required to achieve the above feature shall be included in the Bidder's scope of supply.

- Circuit breaker open/close shall be possible from SCADA and open/close status and all other important signal status shall be provided for SCADA monitoring.

- Power operated mechanism shall be provided with a Universal motor suitable for operation on DC Control supply. In case of DC supply motor should satisfactorily operate with voltage variation between 85% to 110% nominal control supply voltage. Motor insulation shall be class "E" or better.

- The motor shall be such that it requires not more than 30 Seconds for fully charging the closing spring at minimum available control voltage.

- Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.

- The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.

- Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.

- All circuit breakers shall be provided with closing and trip coils. The closing coil shall operate correctly at all values of voltage between 85% to 110% nominal control supply voltage. The trip coil shall operate satisfactorily at all values of voltage between 70% to 110% nominal control supply voltage.

- Provision for mechanical closing of the breaker only in "Test" and "WITHDRAWN" positions shall be made. Alternately, the mechanical closing facility shall be normally made inaccessible; accessibility being rendered only after deliberate removal of shrouds.

- The ACB Panel door shall not be possible to open in breaker closed condition. Further, the racking mechanism shall be accessible only after opening the breaker panel door.

- Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit-breaker module in a cubicle at each location. The trolley shall be such that the top most breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic trolley shall be such that all

type, size and rating of breaker can be withdrawn /inserted of particular switchgear.

- Electrical Parameter of Circuit Breaker

1)	Type	Air break spring charged stored energy type
2)	Operating duty	O-3 MIN-CO-3 MIN-OC
3)	Symmetrical interrupting	As per system fault current (for one sec)
4)	Short circuit rating	2.1 times of System fault current (peak)
5)	Short Circuit Breaking current	
	a) AC Component	As per system fault current (for one sec)
	b) DC Component	As per IEC 60947
6)	Short time withstand	As per system fault current

10.1.7 TEMPERATURE-RISE (For LT Switch-gear having capacity more than 400A)

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

10.1.8 DERATING OF COMPONENTS

The Bidder shall, ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature as per international Standards / Specification. Continuous current rating at 50 deg C ambient in no case shall be less than 90% of the normal rating specified.

The Bidder shall indicate clearly the derating factors if any employed for each component and furnish the basis for arriving at these derating factors duly considering the specified current ratings and ambient temperature of 50 deg C.

10.2 HT SWITCHGEAR

10.2.1 CODES AND STANDARDS

All standards, specification and codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of Techno commercial bid. In case of conflict between this specification and those (International Standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards and codes.

Sl No	IS Code	Name Of Equipment
a)	IEC 60051	AC electricity meters.
b)	IEC 60334	Single phase small AC and universal electrical motors.
c)	IEC 60051	Direct Acting indicating analogue electrical measuring instruments and Accessories.
d)	IEC: 60947	Degree of protection provided by enclosures for low voltage switchgear and control gear.
e)	IEC 60137	Porcelain post insulators for systems with nominal voltages greater than 1000 Volts.
f)	IEC 61869-2	Current transformers.
g)	IEC 61869-3	Voltage Transformers
h)	ISO 10721-2	Code of practice for phosphating of iron and steel.
i)	ISO 6361	Specification for wrought aluminium and aluminium alloy bars, rods, tubes and selections for electrical purposes.
j)	IEC: 61850	Communication Standard for Numerical relays

k)	IEC: 61131-3	Automation Standard for Numerical relays
l)	IEC 60947-3	AC contactors for voltages above 1000 volts and upto and including 11000 Volts.
m)	IEC 60269	Low voltage fuses
n)	IEC 60269	HV fuses
o)	IEC 61439-6	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV
p)	IEC 62271-102	A.C. disconnectors (isolators) and Earthing switches for voltages above 1000 V
q)	IEC 60445/ IEC 60446	Guide for uniform system of marking and identification of conductors and apparatus terminals.
r)	IEC 62271-100	Specification for high voltage AC circuit breakers.
s)	IEC: 60099-4	Metal oxide surge arrestor without gap for AC system
t)	IEC: 62271-100	High voltage alternating current circuit breakers.
u)	IEC: 62271-200	High voltage metal enclosed switchgear and control gear.
v)	IEC: 60947-7-1	Terminal blocks for copper conductors
w)	ISO 3574/ ASTM A1008/A1008M	Cold Rolled Low Carbon Steel Sheets and Strips

10.2.2 TECHNICAL PARAMETERS

A. SYSTEM PARAMETERS		
a)	Nominal System voltage	33kV
b)	Highest System voltage	36kV
c)	Rated Frequency	50Hz
d)	Number of phases/ poles	Three
e)	System neutral earthing	Solidly Earthed
f)	One minute power frequency withstand voltage	
	- for Type tests	70kV
	- for Routine tests	70kV
g)	1.2/50 microsecond Impulse withstand voltage	170kV (peak)
h)	Minimum system fault level	As per System Fault current
i)	Short time rating for bus bars, circuit breakers, current transformers and switchgear assembly.	
j)	Dynamic withstand rating	2.5 times of system fault current
k)	- Space heaters	240 V AC single phase with neutral solidly earthed
l)	Maximum ambient air temperature	50 deg. C
m)	Internal Arc testing	As per system fault current (for Min 1 sec)

B. BUS BARS		
a)	Continuous current rating at 50^{0}C ambient:	As Per Requirement
b)	Temper Rise allowed above ambient	As per IEC 62271-1, 2017

C. SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS

a)	Colour finish	
	Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers)
b)	Cable entry	
	Power Cables	Bottom
	Control Cables	Bottom
c)	Earthing conductor	Galvanized steel strip
d)	Service Continuity of swgrs (LSC2B-PM)	as per IEC 62271-200

D. CIRCUIT BREAKERS		
a)	The circuit breakers current rating shall be selected from the load current at an ambient of 50 deg. C.	
b)	Short circuit breaker Current	
	a) A.C. component	As per system fault current
	b) D.C. component	As per IEC-62271
c)	Short Circuit making current	2.5 times of system fault current (peak)
d)	Operating Duty	O-3 min-CO-3 min-CO
e)	Total break time	Not more than 4 cycles
f)	Total make time	Not more than 5 cycles
g)	Operating Mechanism	Motor wound spring charged stored energy type as per IEC-62271

E. CURRENT TRANSFORMER		
a)	Secondary Current	1A
b)	Class of Insulation	Class E or better
c)	Rated output of each	Adequate for the relays and devices connected, but not less than five (5) VA.
d)	Accuracy class	
	Protection	5P20/PS as per requirement
	Measurement	0.5 class or better as per requirement
e)	Instrument Security Factor for Measurement CTs	5
f)	CT Ratio	CT ratio shall be finalized during details engineering stage. Minimum CT primary side current shall be 110% of rated current.

F. VOLTAGE TRANSFORMERS		
a)	Rated Voltage Factor	1.2 continuous for all VTs, and 1.9 for 8 Hours for star connected VTs.
b)	Class of insulation	Class E or better
c)	Other parameters	0.5 Class or better as per requirement. VA requirement shall be based on application/ requirement. Additional open delta core with damping resistor shall be provided in all VT's to prevent damage on account of Ferro-Resonance conditions
d)	At pooling switchgear, Bus VTs panels and line VTs in outgoing feeders shall be provided. All other switchgear location, at outgoing feeder cable charge indication shall be provided based on voltage sensing or use of voltage transformer.	

G. DIGITAL MFM		
a)	Accuracy Class	0.5 or better
b)	Digital MFM shall be provided for VCB panels as per requirement/SLD.	

10.2.3 SWITCHGEAR PANEL

- The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying with clause No. 3.102 of IEC 62271-200, comprising of a row of free standing floor mounted panels. Each circuit shall have a separate vertical panel with distinct compartments for circuit breaker truck, cable termination, main busbars and auxiliary control devices. The adjacent panels shall be completely separated by steel / Aluzinc sheets except in bus bar compartments where insulated barriers shall be provided to segregate adjacent panels. The Service Class Continuity of Switchgears shall be LSC 2B-PM (as per IEC 622771-200). However, manufacturer's standard switchgear designs without inter panel barriers in busbar compartment may also be considered.

- The circuit breakers and bus VTs shall be mounted on remotely operated withdrawable trucks which shall roll out horizontally from service position to isolated position. For complete withdrawal from the panel, the truck shall rollout on the floor or shall roll out on telescopic rails. In case the later arrangement is offered, suitable trolley shall be provided by the Bidder for withdrawal and insertion of the truck from and into the panel. Testing of the breaker shall be possible in isolated position by keeping the control plug connected.

- The trucks shall have distinct SERVICE and ISOLATED positions. It shall be possible to close the breaker compartment door in isolated position also, so that the switchgear retains its specified degree of protection. Circuit Breaker rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition. While switchboard designs with doors for breaker compartments would be preferred, standard designs of reputed switchgear manufacturers where the truck front serves as the compartment cover may also be considered provided the breaker compartment is

completely sealed from all other compartments and retains the IP-5X degree of protection in the Isolated position. In case the latter arrangement is offered, the Bidder shall explain how this sealing is achieved and shall include blanking covers one for each size of panel per switchboard in his total Techno commercial bid price.

- The switchgear assembly shall be dust, moisture, rodent and vermin proof, with the truck in any position SERVICE, ISOLATED or removed, and all doors and covers closed. All doors, removable covers and glass windows shall have gaskets all round with synthetic rubber or neoprene gaskets.

- The control / relay compartments shall have degree of protection not less then IP 5X in accordance with `IEC 60947. However, remaining compartments can have a degree of protection of IP 5X. All louvers, if provided, shall have very fine brass or GI mesh screen. Tight fitting gourmet / gaskets are to be provided at all openings in relay compartment. Numerical Relays shall be fully Flush mounted on the switchgear panels at a suitable height.

- The Switchgear shall have an internal Arc Classification of IAC FLR corresponding to system fault current. The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Pressure relief device shall be provided in each high voltage compartment of a panel, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of its spreading to other compartments and panels. The pressure relief device shall not however reduce the degree of protection of panels under normal working conditions. To demonstrate that the pressure relief device operates satisfactorily the Contractor shall submit a type test report in line with IEC 62271-200 Annex – A for each high voltage chamber. Wherever louvers are provided, the construction of louvers should be such that the IAC requirements are satisfied. Further, viewing glass windows shall have the same strength as the enclosure against Internal Arc.

- Enclosure shall be constructed with rolled steel / Aluzinc sections. The doors and covers shall be constructed from cold rolled steel sheets of 2.0 mm or higher thickness. Gland plates shall be 2.5 mm thick made out of hot rolled or cold rolled steel sheets and for non-magnetic material it shall be 3.0 mm.

- The switchgear shall be cooled by natural air flow. Forced cooling shall be considered in case current rating is above 2000 A or above.

- The height of switches, pushbuttons and other hand operated devices shall not exceed 1800mm and shall not be less than 700mm.

- Necessary guide channels shall be provided in the breaker compartments for proper alignment of plug and socket contacts when truck is being moved to SERVICE position. A crank or lever arrangement shall preferably be provided for smooth and positive movement of truck between Service and Isolated positions.

- Safety shutters complying with IEC 62271-200 shall be provided to cover up the fixed high voltage contacts on busbar and cable sides when the truck is moved to ISOLATED position. The shutters shall move automatically, through a linkage with the movement of the truck. Preferably it shall however, be possible to open the shutters of busbar side and cable side individually against spring pressure for testing purpose after defeating the interlock with truck movement deliberately. In case, insulating shutters are provided, these shall meet the requirements of IEC 62271-200 and necessary tests as per IEC 62271-200 Clause 5.103.3.3 shall be carried out. A clearly visible warning label "Isolate elsewhere before earthing" shall be provided on the shutters of incoming and tie connections which could be energized from other end.

- Switchgear construction shall have a bushing or other sealing arrangement between the circuit breaker compartment and the busbar / cable compartments, so that there is no air communication around the isolating contacts in the shutter area with the truck in service position.

- The breaker and the auxiliary compartments provided on the front side shall have strong hinged doors. Standard and proven designs of switchgear manufacturers (other than above) shall be reviewed during detailed engineering stage. Busbar and cabling compartments provided on the rear side shall have separate bolted covers with self-retaining bolts for easy maintenance and safety. Breaker compartment doors shall be provided with single-shot latch type handle and shall have locking facility. Suitable interlock shall be provided, which will ensure that breaker is OFF before opening the back doors. Suitable interlock shall be provided to prevent opening of any compartment doors which has any of the MV equipment, in case the supply is ON.

- In the Service position, the truck shall be so secured that it is not displaced by short circuit forces. Busbars, jumpers and other components of the switchgear shall also be properly supported to withstand all possible short circuit forces corresponding to the short circuit rating specified.

- Suitable base frames made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and levelled when the flooring is being done, welding of base frame to the insert plates as per approved installation drawings shall be in Bidder's scope.

10.2.4 CIRCUIT BREAKERS

- The circuit breakers shall be of Vacuum type.
- They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating mechanism.
- Circuit breaker shall be restrike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An anti-pumping relay shall be provided for each breaker, even if it has built-in mechanical anti-pumping features. An arrangement of two breakers in parallel to meet a specified current rating shall not be acceptable.
- During closing, main poles shall not rebound objectionably and mechanism shall not require adjustments. Necessary dampers shall be provided to withstand the impact at the end of opening stroke.
- Plug and socket isolating Contacts for main power circuit shall be silver plated, of self-aligning type, of robust design and capable of withstanding the specified short circuit currents. They shall preferably be shrouded with an insulating material. Plug and socket contacts for auxiliary circuits shall also be silver plated, sturdy and of self-aligning type having a high degree of reliability. Thickness of silver plating shall not be less than 10 microns.
- All working part of the mechanism shall be of corrosion resisting material. Bearings which require greasing shall be equipped with pressure type grease fittings. Bearing pins, bolts, nuts and other parts shall be adequately secured and locked to prevent loosening or change in adjustment due to repeated operation of the breaker and the mechanism.
- The operating mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and shall not lead to closing or tripping of circuit breaker. Failure of any auxiliary spring shall also not cause damage to the circuit breaker or endanger the operator.

- Mechanical indicators shall be provided on the breaker trucks to indicate OPEN / CLOSED conditions of the circuit breaker and CHARGED / DISCHARGED conditions of the closing spring. An operation counter shall also be provided. These shall be visible without opening the breaker compartment door.

- The rated control supply voltage shall be as mentioned elsewhere under technical parameters. The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 85% to 110% rated DC voltage. The shunt trip coil shall operate satisfactorily under all operating conditions of the circuit breaker upto its rated short circuit breaking current at all values of control supply voltage between 70% to 110% of rated DC voltage. The trip coil shall be so designed that it does not get energized when its healthiness is monitored by two indicating lamps (Red) and one trip coil supervision relay.

- The time taken for charging of closing spring shall not exceed 30 seconds. The spring charging shall take place automatically preferably after a closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation. As long as power supply is available to the charging motor a continuous sequence of closing and opening operations shall be possible. One open-close- open operation of the circuit breaker shall be possible after failure of power supply to the motor. Spring charging motors shall be capable of starting and charging the closing spring twice in quick succession without exceeding acceptable winding temperature when the control supply voltage is anywhere between 85% to 110% rated DC voltage. The initial temperature shall be as prevalent in the switchgear panel during full load operation with 50 deg. C ambient air temperature. The motor shall be provided with short circuit protection.

- Motor windings shall be provided with class E insulation or better. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in a hot, humid and tropical climate.

- Circuit breaker shall be provided with inter pole barriers of insulating materials. The use of inflammable materials like Hylam shall not be acceptable.

10.2.5 CONTROLS AND INTERLOCKS

- Rotary type Control switches shall be provided in each switchgear panel. The circuit breaker will normally be controlled from remote control panels through closing and shunt trip coils. The control switch and local control console of the

relay flush mounted on the switchgear would normally be used only for testing of circuit breaker in isolated position, and for tripping it in an emergency. The closing and opening of the breaker shall also be possible from the Laptop through front serial port of the relay to facilitate commissioning activities.

- The basic control scheme shall be developed in the numerical relay using programmable (soft) logics. Tripping of breaker shall be done either through numerical relay or Master Trip Relay.
- Facilities shall be provided for mechanical tripping of the breaker and for manual charging of the stored energy mechanism for a complete duty cycle, in an emergency.
- Each panel shall have two separate limit switches, one for the Service position and the other for isolated position.
- Auxiliary Contacts of breaker may be mounted in the fixed portion or in the withdrawable truck as per the standard practice of the manufacturer, and shall be directly operated by the breaker operating mechanism.
- Auxiliary contacts mounted in the fixed portion shall not be operable by the operating mechanism, once the truck is withdrawn from the service position, but remain in the position corresponding to breaker open position. Auxiliary contacts mounted on the truck portion, and dedicated for Employer's use shall be wired out in series with a contact denoting breaker service position. With truck withdrawn, the auxiliary contacts shall be operable by hand for testing. There shall be at least 2 NO and 2 NC breaker/contactor original Auxiliary contacts made available for the of the Employer's use.
- The contacts of all limit switches and all breaker auxiliary contacts located on truck portion and fixed portion shall be silver plated, rated to make, carry and break 1.0A 240V DC (Inductive) / 10A 240V AC. Contacts of control plug and socket shall be capable of carrying the above current continuously.
- Movement of truck between SERVICE and ISOLATED positions shall be mechanically prevented when the breaker is closed. An attempt to withdraw a closed breaker shall not trip it.
- Closing of the breaker shall be possible only when truck is either in TEST/ISOLATED or IN-SERVICE position and shall not be possible when truck is in between. Further,

closing shall be possible only when the auxiliary circuits to breaker truck have been connected up, and closing spring is fully charged.

- It shall be possible to easily insert breaker of one typical rating into any one of the panels meant for same rating but at the same time shall be prevented from inserting it into panels meant for a different type or rating.

- Indications shall be provided in the relay console flush mounted on the panel front as brought out in the specification elsewhere. It shall be possible to easily make out whether the truck in SERVICE OR ISOLATED POSITION even when the compartment door is closed.

- Reverse blocking and Inter tripping shall be implemented in switchgear boards level. Detailed scheme for the same shall be finalized during detailed engineering stage.

- All required interlock shall be provided for safe operation of switchgears. Capacitive voltage detection or other alternative suitable arrangement (VT shall not be used) shall be used for outgoing feeder backdoor (cable chamber) open interlock.

10.2.6 NUMERICAL RELAYS AND NETWORKING

- Circuit breaker feeders (with protection function as per requirement) shall be provided with SEL make Relays (Communicable Numerical relays) (IED, i.e. Intelligent Electronic Device) complying with SEL3530/IEC-61850 together with SEL2701 ethernet card connected to each bus, having protection, control, and monitoring features. All the SEL make relays connected to each section of the busbar shall be connected to the dedicated SEL3530 communications processor. These relays shall be networked and suitably interfaced with the Solar SCADA system for dynamic SLD display, status monitoring, measurements, event / alarm displays, reports, etc. All intelligent electronic devices (IEDs) connected to the SCADA network shall comply with DNP3 protocol The relays shall be flush mounted on panel front with connections from the inside. These numerical relays shall be of types as proven for the application and shall be subject to Employer's approval. SEL Make Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio and other characteristics to provide required sensitivity. All equipment's shall have necessary protections.

- The SEL make numerical relay shall be capable of measuring and storing values of a wide range of quantities, events, faults and disturbance recordings. The alarm / status of each of protection function and trip operation shall be communicated to Solar SCADA. The numerical relays shall have built in feature / hardware interface to provide such inputs to Solar SCADA / for analog / digital values.

- All SEL make relays shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Contacts for breaker close and trip commands shall be so rated as to be used directly used in the closing and tripping circuits of breaker without the need of any interposing / master trip relays. Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages and typically shall be more than 70% of the rated control supply voltage.

- One minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).

- Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.

- Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.

- All SEL make numerical relays shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts as per the requirement of control schematics. The quantities of such input / outputs shall be finalized during detailed engineering.

- All SEL make numerical relays shall have communications on two ports, local front port communication to laptop and rear port on DNP3/IEC 61850 to communicate with the interface equipment for connectivity with the Solar SCADA. Laptop provided with PCU/SCADA shall be used to facilitate numerical relay configuration, DR and event/fault records downloading from relay locally. Latest version of hardware and Software for interfacing the numerical relays with laptop shall be provided. At least two sets of communication cable for Laptop to relay communication shall be provided.

- All SEL make numerical relays shall have adequate processor memory for implementing the programmable scheme logic required for the realization of the protection / control schemes, in addition to the built in protection algorithms. Numerical relays shall have inrush detection feature for blocking of user selectable protection functions.
- SEL make Numerical relays shall have feature of current measurement. Relay shall be able to provide the same in soft to solar SCADA system.
- SEL make Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.
- Master trip (86) and non-86 trips shall be software configurable to output contacts.
- SEL make Numerical relays used at main pooling switchgear shall have provision of both current and voltage inputs. Number of CT inputs for numerical relays at all switchgear panels shall be as per actual protections requirement but not less than 4 sets, 3 nos. for phase fault & 1 no. for earth fault. Relays shall be suitable for CT secondary current of 1A. All 33kV feeders shall be provided with non-directional EF and OC protection. SEL make Numerical relays used at main pooling switchgear shall have voltage protection and measurement feature.
- Relay setting shall be based on time grading principle with minimum 100mSec shall be the grading margin. Least time setting at inverter transformer feeders and shall be increased towards the evacuation point (towards grid). Relay time setting shall be minimum 100 ms. However, relay current and time setting including time grading margin shall be as per Bidder offered system (with minimum as per above) considering smooth plant operation and proper protection integration/coordination with grid. Bidder can use same relay time setting for tie feeder panels between two switchgears. Relay setting of solar plant feeders shall be done in coordination with 33kV main pooling switch (grid side) relay setting. Any special/other protections, control interlocks etc as per requirement shall be provided by the Bidder. Details shall be finalized during detailed engineering stage.
- For relay setting calculation grid side shall be taken upstream and inverter side shall be taken downstream. For any switchgear outgoing feeder shall be towards grid and incoming feeders shall be towards inverter to be considered.
- All CT & VT terminals on the relays shall be of fixed type suitable for connection of ring-type lugs to avoid any hazard due to loose connection leading to CT open-

circuit. In no circumstances Plug In type connectors shall be used for CT / VT connections.

- All SEL make numerical relay shall have key pad / keys to allow relay settings from relay front. All hand reset relays shall have reset button on the relay front. Relay to be self or hand reset shall be software selectable. Manual resetting shall be possible from remote.
- Relays shall have self-diagnostic feature with self-check for power failure, programmable routines, memory and main CPU failures and a separate output contact for indication of any failure.
- SEL make Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC / ANSI programmable characteristics.
- Design of the relay must be immune to any kind of electromagnetic interference. Vendor shall submit all related type test reports for the offered model along with the offer.
- All cards / hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.
- Relay shall be immune to capacitance effect due to long length of connected control cables. Any external hardware, if required for avoiding mal operation of the relay due to cable capacitance shall be included as a standard feature.
- All I/Os shall have galvanic isolation. Analog inputs shall be protected against switching surges, harmonics etc.
- Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.
- Numerical relays shall have feature for Time synchronization through the SCADA System / networking. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system.
- Ethernet switches shall be suitable to accept both AC & DC supplies with range of 70 % to 120 % of rated voltage.

- Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.

- Bidder to depute relay OEM protection engineer at EFL office for finalization of relay setting and configuration during detail engineering stage. All numerical protection relay configuration and setting shall be done as per approved setting and configuration at switchgear manufacturer work by relay OEM or his authorized representative. All numerical relay testing and logic/interlock checking during commissioning stage at site shall be done under the supervision of Relay OEM or his authorized representative.

10.2.7 OTHER PROTECTIONS AND CONTROL FUNCTIONS IN THE RELAYS

- Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker trip circuit both in pre trip and post trip conditions.

- Schematics requiring auxiliary relays / timers for protection function shall be a part of numerical relay. The number of auxiliary relay and timer function for protection function shall be as required. Timer functions shall be programmable for on/off delays.

- The numerical relay shall be able to provide supervisory functions such as trip circuit monitoring, circuit breaker state monitoring, PT and CT supervisions and recording facilities with Post fault analysis.

- The numerical processor shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.

- At least 200 time tagged events / records shall be stored with time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.

- Diagnostics Automatic testing, power on diagnostics with continuous monitoring to ensure high degree of reliability shall be provided. The results of the self-reset functions shall be stored in battery back memory. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be shall be available on the user interface.

- The alarm/status of each individual protection function and trip operation shall be communicated to solar SCADA.
- Sequence of events shall have 1 ms resolution at device level.
- Measurement accuracy shall be 1 % for RMS Current and voltage.

10.2.8 BUSBARS AND INSULATORS

- All Busbar and jumper connections shall be of high conductivity aluminium alloy. They shall be adequately supported on insulators as per manufacturer's standard proven design to withstand electrical and mechanical stresses due to specified short circuit currents.
- Busbar cross-section shall be uniform throughout the length of switchgear. Busbars and other high voltage connection shall be sufficiently corona free at maximum working voltage.
- Contact surfaces at all joints shall be silver plated or properly cleaned and non-oxide grease applied to ensure an efficient and trouble free connection. All bolted joints shall have necessary plain and spring washers. All connection hardware shall have high corrosion resistance. Bimetallic connectors or any other technically proven method shall be used for aluminium to copper connections.
- Busbar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. Busbar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators. In case of organic insulator partial discharge shall be limited to 100pico coulomb at rated voltage x 1.1 / $\sqrt{3}$. Use of insulators and barriers of in-flammable material such as Hylam shall not be accepted.
- Successful Bidder shall furnish calculation establishing adequacy of busbar sizes for the specified continuous and short time current ratings.
- All busbars shall be color coded.
- The temperature of the busbar and all other equipment, when carrying the rated current continuously shall be limited as per the stipulations of IEC 62271-1,2017, duly considering the specified ambient temperature (50 deg. C).

10.2.9 EARTHING AND EARTHING DEVICES

- A copper / galvanized steel earthing bus shall be provided at the bottom and shall extend throughout the length of each switch board. It shall be bolted/ welded to the framework of each panel and each breaker earthing contact bar.
- A copper / galvanized steel earthing bus shall be provided at the bottom and shall extend throughout the length of each switch board. It shall be bolted/ welded to the framework of each panel and each breaker earthing contact bar.
- The earth bus shall have sufficient cross section to carry the momentary short-circuit and short time fault currents to earth as indicated under switchgear parameters without exceeding the allowable temperature rise.
- Suitable arrangement shall be provided at each end of the earth bus for bolting to Employer's earthing conductors. All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.
- All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical continuity of the whole switchgear enclosure frame work and the truck shall be maintained even after painting.
- The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions i.e. SERVICE and ISOLATED as well as throughout the intermediate travel. The truck shall also get and remain earthed when the control plug is connected irrespective of its position.
- All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering shall not be acceptable. Looping of earth connections which would result in loss of earth connection to other devices, when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths of earth bus is acceptable.
- VT and CT secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit may be removed without disturbing the earthing of other circuits.

- Separate earthing trucks shall be provided by the Contractor for maintenance work. These trucks shall be suitable for earthing the switchgear busbars as well as outgoing / incoming cables or busducts. The trucks shall have a interlock to prevent earthing of any live connection.

- As an alternative to separate earthing trucks the Bidder may also offer built-in earthing facilities for the busbars and outgoing / incoming connections, in case such facilities are available in their standard proven switchgear design. The inbuilt earthing switches shall have provision for short circuiting and earthing a circuit intended to be earthed. These switches shall be quick make type, independent of the action of the operator and shall be operable from the front of the switchgear panel. These switches shall have facility for padlocking in the earthed condition.

- Interlocks shall be provided to prevent :

- Closing of the earthing switch if the associated circuit breaker truck is in Service position.

- Insertion of the breaker truck to Service position if earthing switch is in closed position.

- Closing of the earth switch on a live connection.

- Energizing an earthed Section: Complete details of arrangement offered shall be provided during detailed engineering, describing the safety features and interlocks.

- The earthing device (truck / switch) shall have the short circuit withstand capability equal to that of associated switchgear panel.

- All hinged doors shall be earthed through flexible earthing braid

10.2.10 PAINTING (INDOOR SWITCHGEAR)

All sheet steel work shall be pretreated, in tanks, in accordance with ISO 10721. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphated surfaces shall be rinsed and passivated. After passivation, Electrostatic Powder Coating shall be used. Powder should meet requirements of IEC 60227 (Powder coating specification). Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless

required otherwise by the Employer. The paint thickness shall be 50 microns or more as per the ambient conditions of installation area. Finished parts shall be suitably packed and wrapped with protective covering to protect the finished surfaces from scratches, grease, dirt and oil spots during testing, transportation, handling and erection.

10.2.11 INSTRUMENT TRANSFORMERS

- All current and voltage transformers shall be completely encapsulated cast resin insulated type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 50 deg. C. The class of insulation shall be E or better.

- All instrument transformers shall withstand the power frequency and impulse test voltage specified for the switchgear assembly. The current transformer shall further have the dynamic and short time ratings at least equal to those specified for the associated switchgear and shall safely withstand the thermal and mechanical stress produced by maximum fault currents specified when mounted inside the switchgear for circuit breaker modules.

- The parameters of instrument transformers specified in this specification are tentative and shall be finalized by the Employer in due course duly considering the actual burden of various relays and other devices finally selected. In case the Bidder finds that the specified ratings are not adequate for the relays and other devices offered by him, he shall offer instrument transformer of adequate ratings and shall bring out this fact clearly in his Techno commercial bid.

- All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.

- Current transformers may be multi or single core and shall be located in the cable termination compartment. All voltage transformers shall be single phase type. The bus VTs shall be housed in a separate panel on a truck so as to be fully withdrawable.

- All voltage transformers shall have suitable current limiting fuses on both primary and secondary sides. Primary fuses shall be mounted on the withdrawable portion. Replacement of the primary fuses shall be possible with VT truck in isolated

position. The secondary fuses shall be mounted on the fixed portion and the fuse replacement shall be possible without drawing out the VT truck from service position.

- All voltage transformers shall be designed and manufactured for 0.8 Tesla operating point on B-H curve. VT shall be fully insulated type (i.e. double pole construction and neutral side fully insulated to rated BIL). VT shall be manufactured without any joint in secondary winding.

10.2.12 SURGE ARRESTOR

The surge arrestors shall be provided as per tender SLD/ as per system requirement and shall be of metal oxide, gapless type generally in accordance with IEC 60099-4 and suitable for indoor duty. These shall be mounted within the switchgear cubicle between line and earth, preferably in the cable compartment. Surge arrestor selected shall be suitable for un-earthed system and rating shall be in such a way that the value of steep fronted switching over voltage generated at the switchgear terminals shall be limited to the requirements of switchgear.

10.2.13 CONTROL SUPPLY AND SPACE HEATER SUPPLY

- Each switchboard shall be provided at least two (02) Nos of DC feeders for the control supply.
- In case two DC sources are provided, then suitable rated blocking diodes in both circuit has to be provided. Alternately Bidder can provide source selection switch.
- One suitable rated 240V single phase AC supply feeder per switchboard / Switchboard section for space heater supply. Bidder shall provide necessary switch and fuse to receive, isolate and distribute to each panel.
- Each sub circuit shall have separate fuses. Fuse size shall be determined so as to achieve selective clearance between main circuit and sub circuit in case of fault. Potential circuits for protection and metering shall also be protected by separate fuse.
- All fuses shall be of link type conforming to IEC 60269 mounted on suitable fuse bases. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage. All accessible live connection to fuse bases shall be adequately shrouded.

- All DC circuits shall be fused on both poles. Single phase AC circuits shall have fuses on line and link on neutral.
- DC and AC supply monitoring relay shall be provided and alarm shall be generated in SCADA system in case of failure of supply.

10.2.14 SPACE HEATER

- Each switchgear panel shall be equipped with thermostatically controlled space heater(s), suitably located in breaker and cable compartments to prevent condensation within the enclosure. The space heater shall be connected to 240V single phase AC auxiliary supply available in the switchgear, through switches and fuses provided separately for each panel.
- A 240V single phase 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF switch for connection of hand lamp.

10.2.15 TERMINAL BLOCKS

- Terminal blocks shall be 650V grade, 10Amps rated, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals the screw shall be captive, preferably with screw locking design.
- Terminal blocks for CT and VT secondary leads shall be of stud type, made up of unbreakable polyamide 6.6 grade. They shall be provided with links to facilitate testing, isolation star / delta formation and earthing. Terminal blocks for CT secondary shall have the short circuiting facility. The terminals for remote ammeter connection etc. shall also be disconnecting type only. All metal parts shall be of non-ferrous material. Screws shall be captive.
- At least 10% spare terminals for external connections shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks. Space for adding another 10% spare terminals shall also be available in each panel.
- There shall be minimum clearances of 250 mm between the terminal blocks and the cable gland plate and 150 mm between two rows of terminal blocks.

- All panel wring for external connections shall terminate on separate terminal blocks which shall be suitable for connecting two (2) stranded copper conductors of 2.5 sq. mm on each side, or alternatively, the terminal blocks shall have the possibility of double shorting space to facilitate looping.

10.2.16 SWITCHGEAR WIRING

- All Switchgear panels shall be supplied completely wired internally upto the terminal block ready to receive Employer's external cabling. All inter cubicle wiring and connections between panels of same switchboard including all bus wiring for AC and DC supplies shall be provided / done by the Contractor.

- All internal wiring shall be carried out with 650 V grade, single core, 1.5 sq. mm. stranded copper wires having minimum of seven strands per conductor and color coded, PVC insulation. CT circuits shall be wired with 2.5 sq. mm. wires which otherwise are similar to the above. Extra flexible wires shall be used for wiring between fixed and moving parts such as hinged doors.

- All wiring shall be properly supported neatly arranged, readily accessible and securely connected to equipment, terminals and terminal blocks. Wiring troughs or gutters be used for this purpose.

- Internal wire terminals shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor. Insulation sleeves shall be provided over the exposed parts of lugs.

- Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with applicable international standard. Red Ferrules should be provided on trip circuit wiring.

- Interconnection to adjacent panels shall be brought out to a separate set of terminal blocks located near the slots or holes, meant for the interconnecting wires. Arrangement shall permit neat layout and easy interconnections to adjacent panels at site and wires for this purpose shall be provided by Contractor looped and bunched properly inside the panels.

- Contractor shall be fully responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

- The Contractor shall provide the necessary clamps wiring troughs etc. for all wiring in side the switchgear enclosed including the Employer's power and control cables.

10.2.17 POWER CABLE TERMINATION

- Cable termination compartment shall receive the stranded Aluminium conductor, XLPE insulated, shielded, armoured / unarmoured, PVC jacketed, single core / three core, unearthed / earthed grade power cable(s).

- A minimum clearance of about 600 mm shall be kept between the cable lug bottom ends and gland plates for stress cone formation for XLPE cables. Interphase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnection of cables. Dimensional drawing of cable connection compartment showing the location of lug, glands, CTs, gland plates etc. and the electrical clearances available shall be submitted for Employer's approval during detail engineering.

- Cable termination compartment shall have provision for termination of power cables of sizes as indicated during detailed engineering with removable undrilled gland plates. For all single core cables gland plates shall be of nonmagnetic material. Cable entry shall be from bottom. Any change will be intimated later

10.2.18 Minimum Substation Clearance

Parameter	Requirement
Highest system voltage between phases	36 kV
Minimum clearance between live metal and earth	325 mm
Minimum clearance between live metal of different phases	325 mm
Minimum safety clearance between the nearest point not at earth potential of an insulator to ground (Pedestrian Access)	2300 mm
Minimum safety clearance between live metal and positions to which access is permissible with other conductive equipment	2625 mm

Clearances shall be maximum of what is outlined above or provided as in Australian standard AS 2067.

10.2.19 NAME PLATES AND LABELS

- Each switch board shall have a name plate for its identification. All enclosure mounted equipment shall be provided with individual engraved name plates for clear equipment identification. All panels shall be identified on front as well as backside by large, engraved name plates giving the distinct feeder description along with panel numbers. Back side name plates shall be fixed in panel frame and not on the rear removable cover.

- Name plate shall be of non-rusting metal or 3-ply lamicoid with white engraved letterings, on black background or as per manufacturer's proven standards. Inscriptions and lettering shall be subjected to Employer's approval.

- Suitable stenciled paint mark shall be provided for identification of all equipment, located inside the enclosure, as well as for door mounted equipment, from the back side in addition to plastic sticker labels, if provided. These labels shall be located directly by the side of the respective equipment, shall be clearly visible and shall not be hidden by equipment wiring. Labels shall have device number as mentioned in wiring drawings. Type of labels and fixing of labels shall be such that they are not likely to peel off / fall off during prolonged use.

10.2.20 MODULE DESCRIPTION (Typical)

Sl No	Panel Type	Application	Applicability
1	DB	Transformer Feeder	Transformer Feeder
2	DC	Incomer Feeder	Incomer Feeder
3	DD	Bus Coupler Feeder	Bus Coupler Panel for MV Boards
4	DE-IC	Tie Feeder	Tie Incomer Panel
5	DE-OG	Tie Feeder	Tie Outgoing Panel
6	G	Bus PT	Bus PT Panel

10.2.21 TEST

Type Tests

All equipment to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the following type tests carried out not earlier ten years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

A)	Reports of the following type tests carried out on circuit breaker / circuit breaker panels, of each voltage class and current rating shall be submitted.
i)	Short circuit duty test on circuit breaker, mounted inside the panel offered along with CTs , bushing and separators
ii)	Short time withstand test on circuit breaker, mounted inside panel offered together with CTs, bushings and separators.
iii)	Power frequency withstand test on breaker mounted in side panel.
iv)	Lightning impulse withstand test on breaker mounted in side panel.
v)	Temperature rise test on breaker and panel together. For this test, the test set up shall include three panels with breakers, the test breaker and panel being placed in the centre.
	The adjacent panels shall also be loaded to their rated current capacity. Alternatively the test panel may be suitably insulated at the sides, which will be adjoining to other panels in actual site configuration
vi)	Internal Arc Test as per IEC 62271-200
vii)	Measurement of resistance of main circuit.
viii)	Mechanical operation test.
B)	Short circuit withstand test of earthing device (truck / switch).
C)	Testing to observe compliance to degree of protection, shall be checked for each switch board enclosure and busbar chambers during routine inspection shall be as under. IP -4X: It shall not be possible to insert a one (1) mm. dia steel wire into the enclosure from any direction, without using force. IP-5X: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.

However if the contractor is not able to submit report of the type test(s) conducted not earlier than ten years prior to the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall

conduct all such tests under this contract free of at no additional cost to the owner at third party lab submit the reports for approval.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of EFL, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

Type test reports for the following tests on the model of the Numerical relays, Ethernet switches shall be submitted for employer's review		
Sl. No.	**TEST ITEMS**	**Standard**
i)	Dimensions of structure and visual inspection	IEC 60297-3-101
ii)	Functional requirements:	Relevant IEC 60255-100 series
	– Steady-state simulation	
	– Dynamic simulation	
iii)	Product safety requirements	IEC 60255-27
	(including the dielectric tests and thermal short time rating)	
iv)	EMC requirements:	IEC 60255-26
	– Emission	
	– Immunity	
v)	Energizing quantities:	
	– Burden	N/A
	– Change of auxiliary energizing quantity	IEC 60255-11
vi)	Contact performance	N/A
vii)	Communication requirements	IEC 61850
viii)	Climatic environmental requirements:	IEC 60068-2-14, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-78, IEC 60068-2-30, IEC 60255-27
	– Cold	
	– Dry heat	
	– Change of temperature	
	– Damp heat	
ix)	Mechanical requirements: – Shock	IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3
	– Vibration	
	– Bump	
	– Seismic	

x)	Enclosure protection	IEC 60529, IEC 60255-27

Two (2) protected soft copies on of the approved test results shall be furnished with the equipment. These shall include complete reports and results of the routine tests and type tests (if the latter is carried out) on equipment

Routine Tests

All acceptance and routine tests as per the specification and relevant standards IEC 62271-200 & IEC 62271-100 shall be carried out. Charges for these shall be deemed to be included in the equipment price

An indicative lists of tests / checks is on HT switchgear. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

Commissioning Checks / Tests

After installation of panels, power and Control wiring and connections, Contractor shall perform commissioning checks as listed below to verify proper operation of switchgear / panels and correctness of all equipment in all respects. In addition the Contractor shall carry out all other checks and tests recommended by the manufacturers.

General

(a) Check name plate details according to specification.

(b) Check for physical damage

(c) Check tightness of all bolts, clamps and connecting terminals

(d) Check earth connections.

(e) Check cleanliness of insulators and bushings

(f) Check heaters are provided

(g) H.V. test on complete switchboard with CT & breaker in position.

(h) Check all moving parts are properly lubricated.

(i) Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators.

(j) Check for interchange ability of breakers.

(k) Check continuity and IR value of space heater.

(l) Check earth continuity for the complete switchgear board

Circuit Breakers

(a) Check alignment of trucks for free movement.

(b) Check correct operation of shutters.

(c) Check slow closing operation (if provided)

(d) Check control wiring for correctness of connections, continuity and IR values.

(e) Manual operation of breakers completely assembled.

(f) Power closing / opening operation, manually and electrically at extreme condition of control supply voltage.

(g) Closing and tripping time.

(h) Trip free and anti-pumping operation.

(i) IR values, resistance and minimum pick up voltage of coils.

(j) Simultaneous closing of all the three phases.

(k) Check electrical and mechanical interlocks provided.

(l) Checks on spring charging motor, correct operation of limit switches and time of charging

(m) All functional checks.

Current Transformers

(a) IR value between windings and winding terminals to body.

(b) Polarity tests.

(c) Ratio identification checking of all ratios on all cores by primary injection of current.

(d) Magnetization characteristics & secondary winding resistance.

(e) Spare CT cores, if any to be shorted and earthed.

Voltage Transformers

(a) Insulation resistance test.

(b) Ratio test on all cores.

(c) Polarity test.

(d) Line connections as per connection diagram.

Cubicle Wiring

(a) Check all switch developments.

(b) It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked.

(c) All the wires shall be checked for IR value.

(d) Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component / equipment.

(e) Check terminations and connections.

(f) Wire ducting

10.3 INVERTER DUTY TRANSFORMER

10.3.1 TECHNICAL REQUIREMENT (OIL FILLED TRANSFORMER)

Sr. No.	Transformer	Inverter Transformer
i)	VA Rating & Quantity	As per system requirement
ii)	Voltage Ratio (KV)	As per system requirement
iii)	Duty, Service & Application	Continuous Solar Inverter application and converter duty (Outdoor)
iv)	Winding	AS per system requirement (Only 1/2/4 LV winding)
v)	Frequency	50 Hz
vi)	Nos. of Phase	THREE
vii)	Vector Group & Neutral earthing	As per system requirement/ Inverter Manufacturer recommendation
viii)	Cooling	ONAN
ix)	Tap Changer	As per system requirement OCTC +/- 5% (min.)
x)	Impedance at75^{0}C	
	a) Principal Tap	As per system requirement and SLD* & as per Inverter manufacturer recommendation.
	b) Other Taps	
xi)	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)	
	a) Top Oil	50 deg.C
	b) Each Individual Winding	55 deg.C
xii)	SC withstand time (thermal)	2 sec.
xiii)	Fault Level & Bushing CT	As per system requirement
xiv)	Termination	As per system requirement(LV bushing shall be located on Tank Top)

xv)	Bushing rating, Insulation class (Winding & bushing)	As per relevant IEC (However Inverter Transformer LV side winding & bushing insulation class shall be of at least 3.6 kV) Creepage distance : 35 mm/kV
xvi)	Noise level	AS PER NEMA TR-1
xvii)	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IEC60076-7.
xviii)	Flux density	Not to exceed 1.7 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%
xix)	Air Clearance	IEC 60071
xx)	Foundation	All the foundation shall be designed as per highest rating Transformer in case different capacity transformer are offered.
xxi)	Transformer losses	Total Transformer losses (KW) shall be within 1% of the rated MVA capacity of the transformer. Total Transformer losses (KW) = NLL (KW) + LL(KW) LL: Load Loss (at rated current and temperature of 75 Deg. Celsius @ principal tap)

		NLL: No Load loss (at rated voltage and frequency)

Note (common for Oil filled and dry type transformer):

- Inverter Transformer shall have copper/Aluminum Shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as per relevant applicable standards and Inverter manufacturer recommendation. Also each shield winding shall be taken out to tank with two separate connection from shield to bushing with proper support with 2 nos. 3.6 kV shield bushings and same shall be brought down along with support insulator from tank & copper flat up to the bottom of the tank for independent grounding.
- If Inverter transformer is provided indoor, it shall be necessarily dry type.
- Harmonic Factor as per Inverter manufacturer recommendation must be taken into account while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the dc bias component of 0.5% of rated Inverter output current is to be accounted for its effect on the transformer design.
- The adverse effect on life of transformer due to cloud intermittency and solar generation loading cycle must be compensated through suitable design (as applicable).
- The thermal design of Inverter Transformer needs to consider the temperature dependent performance of the Inverter. It is to in accordance with Inverter output and under worst condition it should not limit Inverter output.
- The multi-winding transformer needs to be designed for long term operating conditions with asymmetrical load on LV side i.e., in case three winding design, the transformer needs to operate reliable with only one Inverter supplying power to only one LV winding.
- For multi winding transformer, it is recommended to have close coupling and equal impedances on each of LV winding to HV winding and to have high enough impedance (8% min. based on one LV winding rating) between two LV windings in order to decouple these windings.

- In case of inverter transformer, it shall be proven and of successfully type tested design
- Contacts from Inverter transformer fittings/protection devices shall be wired for tripping of Inverter transformer Circuit Breaker. Detailed scheme regarding same shall be finalized during detailed engineering.
- Single Line Diagram (SLD) will be finalized during detailed engineering. However, the kVA rating of each LV winding (s) of each inverter transformer shall not be less than maximum kVA capacity of respective Inverters connected to it.

10.3.2 CODES AND STANDARDS

Transformers	IEC:60076
Bushings	IEC:60137, IEC 61109
Insulating oil	IEC 60296, IEC 61099/IS16081
Bushing CTs	IEC 61869, IEC 60185

10.3.3 General Construction

Transformer shall be constructed in accordance to IEC 60076 or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier.

The other important construction particulars shall be as below.

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

b. A double float type Buchholz relay conforming to IEC 60076 shall be provided.

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

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

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

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

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

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

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

10.3.4 Windings

a) The Bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.

b) The conductors shall be of electrolytic grade copper/electrolytic grade Aluminum free from scales & burrs.

c) All windings of the transformers shall have uniform insulation.

d) Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratio.

10.3.5 Core

a) The core shall be constructed from non-ageing, cold rolled, super grain-oriented silicon steel laminations equivalent to M4 grade steels or better.

b) Core isolation level shall be 2 kV (rms.) for 1 minute in air.

c) Adequate lifting lugs will be provided to enable the core & windings to be lifted.

10.3.6 Insulating Mineral oil

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

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm^2/s	£ 12 at 40 ° C £ 1800.0 at (-)30 ° C
2.	Flash Point, ° C	[3] 140° C
3.	Pour point, ° C	£ (-)40 ° C
4.	Appearance	Clear , free from sediment and suspended matter
5.	Density kg/dm^3 at 20 ° C	£ 0.895
6.	Interfacial Tension N/m at 25° C	[3] 0.04
7.	Neutralisation value, mgKOH/g	£ 0.01
8.	Corrosive sulphur	Non Corrosive
9.	Water content mg/kg	£ 30 in bulk supply £ 40 in drum supply

10.	Anti-oxidants additives	Not detectable
11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	 £ 1.2 £ 0.8
12.	Breakdown voltage As delivered, kV After treatment, kV	 [3] 30 [3] 70
13.	Dissipation factor, at 90° C And 40 Hz to 60 Hz	£ 0.005
14.	PCA content	£1%
15.	Impulse withstand Level, kVp	[3] 145
16.	Gassing tendency at 50 Hz after 120 min, mm^3/min	£ 5

Subsequently oil samples shall be drawn at:

Sr. No.	**Parameters**	**Before filling in main tank & tested for**	**Prior to energization for following properties & acceptance norms:**	**Applicability**
i)	BDV	60 kV (min)	60 kV (min)	Applicable for all Transformers.
ii)	Moisture content	10 ppm (max.)	10 ppm (max.)	

10.3.7 Bushings

i. Bushing below 52 kV shall be oil communicating type with porcelain insulator.
ii. LV Bushing below 3.6 kV used within transformer cable box, epoxy type bushing confirming to IEC 60137 also allowed as alternate to porcelain type
iii. No arcing horns to be provided on the bushings.
iv. Inverter Transformer LV bushing palms shall be silver/tin plated.

Bushing CTs

Shall be of adequate rating for protection (differential and others if any) as required, WTI etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

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

Valves

All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies.

Sampling & drain valves should have zero leakage rate.

Gaskets

a) Gasket shall be fitted with weather proof, hot oil resistant, nitrile rubber based gasket.
b) If gasket is compressible, metallic stops shall be provided to prevent over compression.
c) The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

Painting

Parts Name	Type Of Paint	No. of Coats	Total Dft
Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceious iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	One coat each	Atleast 100 micron
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	Two coats each	Atleast 100 micron
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 micron

Neutral Earthing Arrangement

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

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

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

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

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

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

e) The contractor shall provide earthing terminals on the cable box, to suit Employer's GI flat.

f) The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided (shall be discussed during detail engineering). The final cable size, number & length of terminating XLPE cable shall be furnished during detailed engineering.

g) Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).

h) Cable boxes shall have removable top cover (for transformer above 100 KVA) & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

Fittings

Following fittings shall be provided with Transformers covered under this sub section.

a)	-Conservator for main tank (transformer above 100 KVA shall be provided with MOG with low oil level alarm contact), drain valve & indicating type free Cobalt free breather with transparent enclosure (maximum height 1400 mm above ground level) etc.
b)	- Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement (Gas collecting arrangement applicable for transformer above 100 KVA).
c)	- For Auxiliary transformers below 2 MVA, diaphragm type explosion vent shall be provided.
d)	OTI & WTI shall be 150 mm dial type with alarm (WTI only for transformer above 50 kVA) and trip contacts with max. reading pointer & resetting device (maximum height 1500 mm above ground level).
e)	For transformer above 100 KVA: Top & bottom filter valves with threaded male adapters, bottom sampling valve, and drain valve/sludge removal valve at the bottom most point of the tank. For Transformer upto 100 KVA: common drain cum sampling cum bottom filter cum sludge removal valve and top filter valve can be provided.
f)	Air release plug, bushing with metal parts & gaskets, terminal connectors on bushings (as applicable).
g)	Prismatic/toughened glass oil gauge for transformers.
h)	Bi-directional wheel/skids, M.Box, OCTC, Bushing CTs (as applicable), Insulating Oil, Cooling equipment.
i)	Cover lifting eyes, transformer lifting lugs, jacking pads(jacking pad applicable for transformer above 100 KVA), towing holes and core and winding lifting lugs, inspection cover, Bilingual R&D Plate, Terminal marking plates, two nos. earthing terminals etc.
j)	Bolts & nuts (exposed to atmosphere) shall be galvanized steel/SS.
k)	Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.

The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformers are deemed to be included.

Dry Type Inverter Transformer

Sr. No.	Parameters	Inverter Transformer
i)	**Type**	Epoxy cast resin/resin encapsulated
ii)	**Duty, Service & Application**	Continuous Solar Inverter application and converter duty (Indoor)
iii)	**MVA & Voltage ratio**	As per system requirement and SLD.
iv)	**Vector group**	
v)	**Termination & Bushing CT**	
vi)	**Fault Level & Earthing**	
vii)	**Tap changer type & range**	As per system requirement and SLD. OCTC +/-5% (min.)
viii)	**Impedance**	As per system requirement and SLD & as per Inverter manufacturer recommendation.
ix)	**Number of phases**	Three (3)
x)	**Type of cooling**	**AN** Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance guarantee shall correspond to air natural (AN) cooling.
xi)	**Bushing rating, Insulation class (Winding & bushing)**	As per relevant IEC (However Inverter Transformer LV side winding & bushing insulation class shall be of at least 3.6 kV)
xii)	**Maximum Temperature rise of winding over 50 deg. C ambient. (by resistance method) with Air Natural (AN) cooling.**	**90** deg.C. (class F) **115** deg.C. (class H)
xiii)	**SC withstand time (thermal)**	2 sec

xiv)	**Noise Level**	Not to exceed values specified in NEMA TR-1.
xv)	**PD Level (max. Allowable)**	10 pc
xvi)	**Loading Capability**	Continuous operation at rated KVA on any tap with voltage variation of +/-10% corresponding to the voltage of the tap as well as in accordance with IEC60076-12/
xvii)	**Flux Density**	Not to exceed 1.9 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds.

Codes And Standards

Dry type transformers	IEC 60076-11

Design And Constructional Features

- The core shall be constructed from high grade non-ageing cold rolled grain-oriented silicon steel laminations of M4 grade or better quality. The insulation of core to clamp-plates shall be able to withstand a power frequency voltage of 2 kV (rms) for one (1) minute.

- The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23. In case it is placed outdoor, IP for enclosure shall be minimum IP-42 or higher. Enclosure shall be of a tested quality sheet steel of minimum thickness 2mm & shall also accommodate cable terminations. The housing door shall be interlocked such that it should be possible to open the door only when transformer is off. The enclosure shall be provided with lifting lugs and other hardware for floor mounting. Suitable bi-directional skids

with pre-drilled holes shall be provided integral with the enclosure or bi-directional rollers shall be provided with suitable locking arrangement.

- Winding conductor shall be electrolytic grade Copper/ Aluminum. Windings shall be of class F insulation or better. All windings are to be uniformly insulated.
- Transformer HV bushings and LV bushings can be either solid porcelain or epoxy type. Bushing shall be suitable for satisfactory operation in the high ambient temperature inside Bus Duct enclosure (if applicable). LV flange area shall be of non-magnetic material.
- Bushing CTs shall be provided in the LV neutral side of adequate rating for REF protection, WTI, etc (as applicable).
- For Marshalling Box the sheet steel used shall be at least 1.6 mm thick cold rolled. The box shall be tank mounted type. The degree of protection shall be IP-54 in accordance with IEC 60947 Wiring Scheme shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.
- Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance shall correspond to air natural cooling.

Painting

The inside of enclosure and accessories (except M. Box) shall be painted with two coats of fully glossy white colour with total DFT of 25 to 60 microns. The external paint colour of transformer & accessories shall be blue corresponding to RAL 5012. The external surface of transformer & accessories shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of polyurethane finish paint with total DFT of 80 to 150 microns. The internal surface of M.Box shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of chemical & thermal resistant epoxy enamel white paint with total DFT of 80 to 150 microns.

Fitting

Winding temperature indicator (WTI)	Shall be Platinum resistance type temperature detector in each limb. Single Indicating meter may be provided for display of

	temperature of all limbs. Accuracy class of Indicating meter shall be +/- 1% or better and it shall have least count of 0.1 °C or better. 1 no. 4-20 mA signal shall be provided for remote monitoring of winding Temperature.
RTD/Thermistors	1 No. PT-RTD shall be embedded in each limb with alarm and trip contacts for remote annunciation. Additional 1 No. thermistor/RTD shall be embedded in each limb.
Fittings which are generally required for satisfactory operation of the transformers are deemed to be included, in the scope of supply of the Contractor.	

Tests And Inspection

In case the bidder/contractor has conducted type test(s) within last ten years, he may submit the type test reports to the owner for waiver of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

In case the Bidder is not able to submit report of the type test(s) conducted within last ten years from the date LOA by EFL, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract at no additional cost to the Employer and submit the reports for approval

Short Circuit Test:-

In case short circuit test has not been conducted or the test report not meeting the specification requirement for the offered transformer manufacturer, Bidder /Sub-vendor shall establish" Ability to withstand the dynamic effects of short circuit "for the offered transformer as per latest IEC 60076-5.The ability to withstand the dynamic effects of short circuit can be established either by performing actual short circuit test or by method of calculation with reference to short circuit tested reference transformer as per IEC-60076-5/Annexure-A&B. Bidder shall choose any one the two options mentioned below;

Option-1:- Performing actual short circuit test as Type Test. In order to meet project schedule, Bidder/Sub vendor shall take suitable steps quite in advance to ensure successful conduction of short circuit test within three months time from date of LOA failing which the offered make of the transformer shall not be considered.

Option-2: By theoretical evaluation of the ability to withstand dynamic effect of short circuit based on 'Calculation and Design and Manufacture Consideration'. In this regard the guidelines given in Annexure-A with applicable tables of the IEC 60076-5 is to be followed. The reference transformer chosen shall be of same application, winding configuration, conductor current density and as per Annexure-B of latest IEC-60076-5. Necessary Design document and reference test reports related to theoretical comparative evaluation must be submitted by Manufacturer/Bidder as required by Employer in this case.

S.N.	Routine Tests	
1.	All routine test shall be carried out in accordance with IEC 60076.	√
2.	Measurement of Voltage Ratio & phase displacement (as per IEC 60076-1)	√
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	√
4.	Vector group and Polarity Check (as per IEC 60076-1)	√
5.	Magnetic Balance and Magnetizing Current Test	√
6.	Measurement of no load current with 415 V, 50 Hz AC supply	√
7.	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage (as per IEC 60076-1)	√
8.	Load Loss & Short Circuit Impedance Measurement on principal & Extreme Taps	√
9.	IR measurement (As per IEC 60076-1)	√
10.	Measurement of capacitance & tan delta to determine capacitance between winding & earth.	√
11.	Separate Source Voltage Withstand Test /Applied voltage test (as per IEC 60076-3)	√
12.	Induced overvoltage test/Induced voltage withstand (IVW) test as per IEC60076 part 3	√
13.	Repeat no load current/loss & IR after completion of all electrical test	√
14.	Oil leakage test on completely assembled transformer along with radiators (as per relevant clause of this sub section)	√
15.	Jacking test followed by D.P. test	√

S.N.	Routine Tests	
16.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	√
17.	IR measurement on wiring of Marshalling Box.	√

S. N.	Type Tests # (To be carried out on one transformer of each rating)	
1.	Lightning impulse (Full and chopped wave) test on windings (as per IEC 60076-3) (Not applicable for LV)	√
2.	Short circuit test (special test) as per IEC 60076-5 (if applicable).	√
3.	Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076. Gas Chromatography shall be conducted on oil sample taken before & immediately after temp. rise test. Gas analysis shall be as per IEC: 60567), results will be interpreted as per IEC: 60599).	√
4.	Measurement of harmonics of no-load current (special test)	√
5.	Measurement of acoustic noise level as per NEMA TR-1 (special test)	√
6.	Tank Vacuum & Pressure Test (as per CBIP norms)	√

(#) NOTE:-

i. All the type and special tests shall be conducted after performing Short Circuit Test. If Tank Vacuum & Pressure Test is to be carried out then it shall be conducted before SC test.

ii. Inverter Transformer LV winding Di-electric tests (except for lightning impulse test for LV winding) shall be carried out corresponding to levels (as per IEC 60076) for 3.6 kV class.

iii. All Type tests should be done as per Employer's approved procedure.

Leakage test on assembled Oil filled Transformer (Routine Test)

All tank & oil filled compartment shall be tested for oil tightness by being completely filled with oil of viscosity not greater than that of specified oil at the ambient temperature & applying pressure equal to the normal pressure plus 35 KN/sq. m measured at the base of the tank. The pressure shall be maintained for a period of not

less than 6 hours during which time no sweating shall occur. Bidder can perform this test at site depending upon urgency subject to EFL approval.

Statutory requirement- Suitable Fire Fighting arrangements for Oil filled Transformers shall be provided if applicable as per Australia / New Zealand safety regulation /statutory requirements. In case Nitrogen based fire protection system is used, Fiji standard shall be followed for compliance. Firewall & soak pit as applicable (as per statutory requirement/) shall be provided of minimum 230 mm thickness of RCC wall or 355 mm thick fire resisting brick wall subject to EFL approval. However, for all oil filled outdoor transformers, a pit shall be provided all around at a distance of 1.0 meter (min.) from transformer outer edge including sump pit. Transformer efficiency shall be as per latest Australia / New Zealand regulation and notification

Routine / Type Tests (Dry Type Transformers)

Transformer shall be short circuit tested after conducting the routine tests. Rest of the type tests shall be conducted after successful short circuit testing. All routine tests in accordance with IEC 60076-11 shall be carried out on each transformer and All Type tests should be done as per Employer's approved procedure.

Routine / Type Tests (Dry Type Transformers)			
a.)	Measurement of winding Resistance for each tap position.		Routine
b.)	Measurement of voltage ratio at each taps position.		Routine
c.)	Vector group and polarity check		Routine
d.)	Measurement of impedance voltage/short circuit impedance & load loss at principal tap and extreme taps		Routine
e.)	Measurement of no load losses and magnetizing current at rated frequency and 90%, 100% and 110% rated voltage.		Routine
f)	Measurement of insulation resistance		Routine
g)	Measurement of capacitance and tan delta		Routine
h)	Dielectric Tests		
	1)	PF/Separate source AC withstand voltage test.	Routine
	2)	Chopped wave lightning impulse voltage test on windings(as per IEC 60076-3) (Not applicable for LV)	Type
	3)	Induced over voltage withstand test	Routine
i)	Partial discharge measurement		Routine

j)	Measurement of iron loss & IR (repeat after induced voltage test)	Routine
k)	Short Circuit test as per IEC (if applicable)	Type
l)	Noise Level Measurement	Type
o)	Temperature rise test as per IEC (HV & LV winding)	Type

10.4 AUXILIARY TRANSFORMER

10.4.1 TECHNICAL REQUIREMENT (OIL FILLED TRANSFORMER)

Sr. No.	Description	Auxiliary Transformer
i)	VA Rating & Quantity	As per system requirement
ii)	Voltage Ratio (KV)	As per system requirement
iii)	Duty, Service & Application	Continuous application (Outdoor)
iv)	Winding	TWO
v)	Frequency	50 Hz
vi)	Nos. of Phase	THREE
vii)	Vector Group & Neutral earthing	As per system requirement
viii)	Cooling	ONAN
ix)	Tap Changer	As per system requirement
x)	Impedance at75^{0}C	
	a) Principal Tap	As per system requirement
	b) Other Taps	
xi)	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)	
	a) Top Oil	35 deg.C
	b) Winding	40 deg.C
xii)	SC withstand time (thermal)	2 sec.
xiii)	Fault Level & Bushing CT	As per system requirement
xiv)	Termination	As per system requirement /cable box

xv)	Bushing rating, Insulation class (Winding & bushing)	As per relevant IEC Creepage distance: 35 mm/kV
xvi)	Noise level	AS PER NEMA TR-1
xvii)	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS: 6600.
xviii)	Flux density	Not to exceed 1.7 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%

Note (common for Oil filled and dry type transformer):

- Auxiliary transformers shall be suitable for 3 phase, 4 wire system with additional LVN bushing for equipment earthing.
- Auxiliary Transformer can be either Oil Natural/Synthetic Ester oil) filled or Dry Type (refer relevant specification).
- In case Ester Oil filled Transformers are offered, then 50% quantity shall be Natural ester filled and balance 50% quantity shall be of Synthetic Ester oil filled.

10.4.2 CODES AND STANDARDS

Transformers	IEC 60076
Bushings	IEC 60137
Insulating oil	IEC 62109, IEC 61727, IEC62116,
Bushing CTs	IEC 61869

10.4.3 General Construction

Transformer shall be constructed in accordance to IEC 60076or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier.

The other important construction particulars shall be as below.

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

b. A double float type Buchholz relay conforming to IEC 60076 shall be provided.

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

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

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

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

g. Transformer shall have Oil Temperature Indicator and Winding temperature Indicator (WTI applicable for transformer above 50 KVA) with accuracy class of +/-2 deg.

h. For Transformers above 100KVA, radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/valve at the bottom and air release plug at the top.

i. M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level (for transformer above 100 KVA). For transformer above 100 KVA, wiring scheme (TB details) shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

j. In case Natural Ester oil (IEC 61126/IEC 61727/IEC 62109) filled transformer, the Transformer should be hermetically sealed and corrugated tank design. It should fitted with monitoring equipment like DGPT etc. for accessing the healthiness of Natural ester oil. As transformer becomes hermetically sealed, fitting, valves and accessories shall be decided during detail engineering but all other part of tender specification related to design of transformer active part and testing requirement shall remain same. HV/LV Bushing shall be fitted vertically on tank cover and all necessary measures to be taken to make the transformer leakage proof. Suitable nitrogen capping system shall be provided for preserving Natural ester oil for O&M.

10.4.4 Windings

a) The bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.

b) The conductors shall be of electrolytic grade copper free from scales & burrs.

c) All windings of the transformers shall have uniform insulation.

d) Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratios.

10.4.5 Core

a) The core shall be constructed from non-ageing, cold rolled, super grain-oriented silicon steel laminations equivalent to M4 grade steels or better.

b) Core isolation level shall be 2 kV (rms.) for 1 minute in air.

c) Adequate lifting lugs will be provided to enable the core & windings to be lifted.

10.4.6 Insulating Mineral oil

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

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm^2/s	£ 12 at 40 ° C £ 1800.0 at (-)30 ° C
2.	Flash Point, ° C	[3] 140° C
3.	Pour point, ° C	£ (-)40 ° C
4.	Appearance	Clear , free from sediment and suspended matter
5.	Density kg/dm^3 at 20 ° C	£ 0.895
6.	Interfacial Tension N/m at 25° C	[3] 0.04
7.	Neutralisation value, mgKOH/g	£ 0.01
8.	Corrosive sulphur	Non Corrosive
9.	Water content mg/kg	£ 30 in bulk supply £ 40 in drum supply
10.	Anti-oxidants additives	Not detectable
11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	 £ 1.2 £ 0.8
12.	Breakdown voltage As delivered, kV After treatment, kV	 [3] 30 [3] 70
13.	Dissipation factor, at 90° C And 40 Hz to 60 Hz	£ 0.005
14.	PCA content	£1%
15.	Impulse withstand Level, kVp	[3] 145
16.	Gassing tendency at 50 Hz after 120 min, mm^3/min	£ 5

Subsequently oil samples shall be drawn at:

Sr. No.	Parameters	Before filling in main tank & tested for	Prior to energization for following properties & acceptance norms:	Applicability
i)	BDV	60 kV (min)	60 kV (min)	Applicable for all Transformers.
ii)	Moisture content	10 ppm (max.)	10 ppm (max.)	

For ester filled oil, relevant IEC shall be followed for relevant oil parameters for type/routine test.

10.4.7 Bushings

a) Bushing below 52 kV shall be oil communicating type with porcelain insulator.

b) No arcing horns to be provided on the bushings.

Bushing CTs

Shall be of adequate rating for protection as required, WTI (WTI CT applicable for transformer above 50 KVA) etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

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

Valves

All valves up to and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies.

Sampling & drain valves should have zero leakage rate.

Gaskets

a) Gasket shall be fitted with weather proof, hot oil resistant, rubberized cork gasket.

b) If gasket is compressible, metallic stops shall be provided to prevent over compression.

c) The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

Painting

Parts Name	**Type Of Paint**	**No. of Coats**	**Total Dft**
Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceious iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	One coat each	Atleast 100 micron
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	Two coats each	Atleast 100 micron
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 micron

Neutral Earthing Arrangement

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

Cable boxes & disconnecting chamber (Disconnecting chamber applicable 3.3 kV and above)

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

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

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

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

(e) The contractor shall provide earthing terminals on the cable box, to suit Employer's GI flat.

(f) The minimum length provided for terminating 33 kV, 11KV & 3.3 KV XLPE cable shall be 1000 mm (for 33 kV) 650 mm (for 3.3 kV and 11 kV) from cable gland plate to the cable lug) for the cable boxes, for 433V side suitable length shall be provided (shall be discussed during detail engineering). The final cable size, number & length of terminating XLPE cable shall be furnished during detailed engineering.

(g) Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).

(h) Cable boxes shall have removable top cover (for transformer above 100 KVA) & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

Fittings

Following fittings shall be provided with Transformers covered under this sub section.

a)	-Conservator for main tank (transformer above 100 KVA shall be provided with MOG with low oil level alarm contact), drain valve & indicating type free Cobalt free breather with transparent enclosure (maximum height 1400 mm above ground level) etc.
b)	- Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement (Gas collecting arrangement applicable for transformer above 100 KVA).
c)	- For Auxiliary transformers below 2 MVA, diaphragm type explosion vent shall be provided.
d)	OTI & WTI shall be 150 mm dial type with alarm (WTI only for transformer above 50 kVA) and trip contacts with max. reading pointer & resetting device (maximum height 1500 mm above ground level).
e)	For transformer above 100 KVA: Top & bottom filter valves with threaded male adapters, bottom sampling valve, and drain valve/sludge removal valve at the bottom most point of the tank. For Transformer upto 100 KVA: common drain cum sampling cum bottom filter cum sludge removal valve and top filter valve can be provided.
f)	Air release plug, bushing with metal parts & gaskets, terminal connectors on bushings (as applicable).
g)	Prismatic/toughened glass oil gauge for transformers.
h)	Bi-directional wheel/skids, M.Box, OCTC, Bushing CTs (as applicable), Insulating Oil, Cooling equipment.
i)	Cover lifting eyes, transformer lifting lugs, jacking pads(jacking pad applicable for transformer above 100 KVA), towing holes and core and winding lifting lugs, inspection cover, Bilingual R&D Plate, Terminal marking plates, two nos. earthing terminals etc.
j)	Bolts & nuts (exposed to atmosphere) shall be galvanized steel/SS.
k)	Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.

The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformers are deemed to be included.

Tests and Inspection

S.N.	Routine Tests	
1.	All routine test shall be carried out in accordance with IEC 60076.	√
2.	Measurement of Voltage Ratio & phase displacement	√
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	√
4.	Vector group and Polarity Check	√
5.	Magnetic Balance and Magnetising Current Test	√
6.	Measurement of no load current with 415 V, 50 Hz AC supply	√
7.	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage	√
8.	Load Loss & Short Circuit Impedance Measurement on principal & Extreme Taps	√
9.	IR measurement (As per IEC 60076-1)	√
10.	Separate Source Voltage Withstand Test /Applied voltage test.	√
11.	Induced overvoltage test/Induced voltage withstand (IVW) test .	√
12.	Repeat no load current/loss & IR after completion of all electrical test	√
13.	Oil leakage test on completely assembled transformer along with radiators (as per relevant clause of this sub section)	√
14.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	√
15.	IR measurement on wiring of Marshalling Box.	√
S.N.	**Type Tests**	
1.	Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076.	√
2.	Tank Vacuum & Pressure Test (as per CBIP norms)	√

Leakage test on assembled Oil filled Transformer (Routine Test)

All tank & oil filled compartment shall be tested for oil tightness by being completely filled with oil of viscosity not greater than that of specified oil at the ambient temperature & applying pressure equal to the normal pressure plus 35 KN/sq. m measured at the base of the tank. The pressure shall be maintained for a period of not less than 6 hours during which time no sweating shall occur. Bidder can perform this test at site depending upon urgency subject to EFL approval

Fire Fighting

Firewall & soak pit as applicable (as per Local statuary requirement/TAC/IEEE C57.125 / C57.93/ & IEC 60364) shall be provided of minimum 230 mm thickness of RCC wall or 355 mm thick fire resisting brick wall subject to EFL approval. However for all outdoor transformer at a distance of 1.0 m (min.) from transformer outer edge. A sump pit shall be provided for each pit. Transformer efficiency shall be as per AUSTRALIA /NEW ZEALAND REGULATION AND GUIDELINES

DRY TYPE AUXILIARY TRANSFORMERS:

Dry Type Transformer shall be constructed in accordance to IEC 60076 or equivalent to any other international standard, Australia or New Zealand notifications & GUIDELINES. Transformer rating and all related technical parameters including tap changer (if applicable) shall be as per system requirement/SLD and relevant standards. Transformer shall be suitable for continuous indoor duty application. Transformer shall be complete & functional in all respect. The other important construction particulars shall be as below.

a) The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23. The enclosure shall be provided with suitable hardware (as required).

b) The conductors shall be of electrolytic grade copper free from scales & burrs.

c) Dry Type Transformer windings shall be of class F insulation or better. Cooling shall be AN.

d) The core shall be constructed from non-ageing, cold rolled, grain oriented silicon steel laminations (M4 or better).

The fittings/accessories including protection/monitoring device (temperature scanner) generally required for satisfactory operation of the transformer, are to be provided.

10.5 AC CABLES

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IEC 60502IEC 60502	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.
IEC 60502IEC 60502	Cross linked polyethylene insulated PVC sheathed cable for (Part -II) working voltage from 3.3 KV upto & including 33 KV
–ISO 228	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IEC 60287	Recommended current ratings for cables
IEC 60502/IEC 60888	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IEC 60227/IEC 60502	PVC insulation and sheath of electrical cables.
IEC 60228	Conductors for insulated electrical cables and flexible cords.
IEC 60811	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332 Part-3:	Tests on electric cables under fire conditions. Tests on bunched wires or cables (Category-B).
IEEE-383	Standard for type test of Class IE Electric Cables

ISO 24153/ISO 2859	Methods for random sampling.
IEC 60304/IEC 60445	Specification for drums for electric cables.

10.5.1 GENERAL REQUIREMENTS:

The cables shall be suitable for laying on racks, in ducts, trenches, conduits, overground cabling and underground (buried) installation with chances of flooding by water.

All cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.

a) Cables shall be armored type if laid in switchyard area or directly buried.
b) Cable lengths shall be considered in such ways that straight through cable joints are avoided.
c) If cables are to be laid underground, laying shall be as per latest relevant IEC code.
d) If cables are to be laid overground (eg on RCC/concrete pedestals etc), the cables shall be UV-resistant supported by test reports.

10.5.2 CONDUCTOR

Copper/aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.

10.5.3 INSULATION

XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C. PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.

The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core cables, shall have distinct extruded PVC inner sheath of black colour as per iec 60227IEC 60227.

10.5.4 ARMOUR

For single core armoured cables, armouring shall be of copper/aluminium wires/ formed wires. For multicore armoured cables, armouring shall be of galvanised steel as follows:

Calculated nominal dia.of cable under armour	Size and Type of armour
Upto 13 mm	1.4mm dia GS wire
Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire / 3.15mm dia GS wire
Above 70mm	1.4mm thick GS formed wire / 4.0 mm dia GS wire

The aluminium used for armouring shall be of H4 grade as per IEC 60502 with maximum resistivity of 0.028264 ohm mm2 per meter at 20 deg C. The sizes of aluminium armouring shall be same as indicated above for galvanized steel.

The gap between armour wires / formed wires shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of GS wire / formed wire.

10.5.5 OUTERSHEATH

Outer sheath shall be of PVC as per IS: IEC 60227 & black in colour for power cables. In addition to meeting all the requirements of FIJI standards referred to, outer sheath of all the cables shall have the following FRLS properties.

Oxygen index of min. 29 (as per IEC 60332/ISO 4589).

Acid gas emission of max. 20% (as per IEC-754-I).

Smoke density rating shall not be more than 60 % (as per ASTMD-2843).

In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath.

Cable size and voltage grade - To be embossed

Word 'FRLS' at every 5 metre - To be embossed

Screen Fault current _ _ _KA for _ _ _ Sec. (Value of current & time shall be indicated) (If applicable)

Sequential marking of length of the cable in metres at every one metre -To be embossed / printed

The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

All cables shall meet the fire resistance requirement as per IEEE - 383 with cable installations made in accordance with 'Flammability Test' and as per Category-B of IEC 332 Part -3.

Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum, over the declared value in the technical data sheets.

Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

10.5.6 CABLE SELECTION & SIZING

Cables shall be sized based on the following considerations:

a) Rated current of the equipment

b) The Maximum Overall Voltage Drop: As per Standard

c) Short circuit withstand capability

d) Fault current- As per system fault current.

10.5.7 DERATING FACTORS

De rating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

a) Variation in ambient temperature for cables laid in air

b) Grouping of cables

c) Variation in ground temperature and soil thermal resistivity for buried cables.

10.5.8 HT POWER CABLES

For single-core armoured cables, the armouring may constitute the metallic part of insulation screening

In case of single core cables where there are both metallic screening and armouring, there shall be extruded inner sheath between them.

Distinct extruded PVC inner sheath of black colour as per IEC 60227IEC 60227 shall be provided for the cables as follows:

a) For all multicore cables.

b) For single core armoured cables, where armouring is not being used as metallic screen Cores of the cables of upto 3 cores shall be identified by colouring of insulation or by providing coloured tapes helically over the cores with Red, Yellow & Blue colours.

The cross-sectional area of the metallic screen strip/tape shall be considered in design calculations.

The eccentricity shall be calculated as

Eccentricity	Ovality
$\frac{t_{max} - t_{min}}{t_{max}} \times 100$	$\frac{d_{max} - d_{min}}{d_{max}} \times 100$
Where t-max/t-min is the maximum/minimum thickness of insulation and d-max/d-min is the maximum / minimum diameter of the core	

The eccentricity of the core shall not exceed 10% and ovality not to exceed 2%.

Cables shall conform to –IEC 60502-2. These cables shall have mutli-stranded, compacted circular, aluminium conductors, XLPE insulated, metallic screened suitable for carrying the system earth fault current, PVC outer sheathed. The conductor screen and insulation screen shall both be of extruded semiconducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process so as to obtain continuously smooth interfaces. Method of curing for cables shall be "dry curing / gas curing".

The metallic screen of each core shall consist of copper tape with minimum overlap of 20%. However for single core armoured cables, the armouring shall constitute the metallic part of the screening.

The standard length for HT power cables shall be 1000 meter for all single core cables and 750 meters for 3 core cables. The length per drum shall be subjected to a maximum tolerance of +/- 5% of the standard drum length. The Employer shall have the option of rejecting cable drum with shorter lengths. One drum length of each cable size can be of non standard length (not less than 250 meter) so as to match the ordered quantity. For each size, the variance of total quantity, adding all the supplied drum lengths, from the ordered quantity, shall not exceed +/-2% and the payment shall be made based on the actual cable length supplied within this limit.

10.5.9 LT POWER CABLES

LT Power & control cables shall be of minimum 1100 volts grade XLPE /PVC insulated conforming to IEC 60227/IEC60502 (Part-I) for utilization voltages less than equal to 415 V.

For cable connecting central inverter and inverter transformer, no. of runs and interconnecting trench, bus bar terminations, lugs shall be provided in such a manner so that no overheating of contacts & terminals encountered. Sufficient space for cabling & termination shall be kept.

The sizing of the cable will depend on the feeder type. For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse. For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.

Single core cables shall have no Inner sheath as per IEC 60502

All LT power cables of sizes more than 120 sq.mm. shall be XLPE insulated.

1.1 KV grade XLPE power cables shall have compacted aluminium/ copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), armoured/ unarmoured, PVC outer-sheathed conforming to IEC 60502. (Part-I). Cables which are directly buried shall be armoured.

1.1KV grade PVC power cables shall have aluminium/copper conductor (compacted type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed (as applicable) armoured/ unarmoured, PVC outer-sheathed conforming to IS:1554 (Part-I).

10.5.10 LT CONTROL CABLES

Conductor of control cables shall be made of stranded, plain annealed copper.

Outer sheath shall be of PVC as per IEC 60227 & grey in colour for control cables.

Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

1 core - Red, Black, Yellow or Blue
2 core- Red & Black
3 core-Red, Yellow & Blue
4 core-Red, Yellow, Blue and Black

For control cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The number shall be printed in english numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of insulation. The colour of insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.

CABLE SELECTION & SIZING:

Control cables shall be sized based on the following considerations:

(a) The minimum conductor cross-section shall be 1.5 sq.mm.

(b) The minimum number of spare cores in control cables shall be as follows:

No. of cores in cable	Min. No. of spare cores
2C, 3C	NIL
5C	1
7C-12C	2
14C & above	3

1.1 KV Grade Control Cables shall have stranded copper conductor and shall be multicore PVC or XLPE insulated, PVC inner sheathed, armoured / unarmoured, FRLS PVC outer sheathed conforming to IEC 60227/ IEC 60502. (Part-I).

10.5.11 TESTS

Indicative list of tests/checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of power and control cables enclosed at relevant section.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. All cables to be supplied shall be of type tested design.

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

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

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of EFL, an endorsement sheet will be furnished by the

manufacturer confirming similarity and “No design Change”. Minor changes if any shall be highlighted on the endorsement sheet.

The reports for following type tests shall be furnished:

Sl	Type Test	Remarks
	Conductor	
1.	Resistance test	
	For Armour Wires / Formed Wires	
2.	Measurement of Dimensions	
3.	Tensile Test	
4.	Resistance test	
5.	Wrapping test	
6.	Torsion test	For GS round wires only
7.	Elongation test	For GS wire only
8(a)	Mass& uniformity of Zinc Coating tests	For GS wires/formed wires only.
8(b)	Adhesion test	For GS wires/formed wires only
	For XLPE insulation & PVC Sheath	
9.	Test for thickness	
10.	Tensile strength and elongation test before ageing and after ageing	
11.	Ageing in air oven	
12.	Shrinkage test	
13	Hot set test	For XLPE insulation only
14	Water absorption test	For XLPE insulation only
15.	Loss of mass test	For PVC outer sheath only.
16.	Hot deformation test	For PVC outer sheath only.
17.	Heat shock test	For PVC outer sheath only
18.	Thermal stability test	For PVC outer sheath only
19.	Oxygen index test	For PVC outer sheath only
20.	Smoke density test	For PVC outer sheath only
21.	Acid gas generation test	For PVC outer sheath only

Sl	Type Test	Remarks
22	Flammability test as per IEC-332 Part-3 (Category -B)	For completed cable only
23	Insulation resistance test (Volume Resistivity method)	
24	High voltage test	
25. *	Partial discharge test	For HT cables only
26. *	Bending test	
27. *	Dielectric power factor test	
	a) As a function of voltage	
	b) As a function of temperature	
28. *	Heating cycle test	
29. *	Impulse withstand test	

* Not applicable for 3.3/3.3kV grade cables.

10.5.12 CABLE DRUMS

(a) Cables shall be supplied in wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. However, For Single core cables upto 6 Sq. mm size, supplier can do alternative packaging of whole Drum/Spool to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with ISO 780 / ISO 12048.

Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled

10.6 CABLE INSTALLATION METHODOLOGY

10.6.1 CODES AND STANDARDS

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards/ codes as applicable.

Standard	Description
SAE 1008 / ASTM A1008	Cold-rolled low-carbon steel sheets and strips.
ASCE Manual 52 / IEC 60826	Code of practice for the use of structural steel in overhead transmission line towers.
EN 10111 / EN 10025	Hot-rolled carbon steel sheets and strips.
EN 10255 / EN 10242	Mild steel tubes, tubulars, and other wrought steel fittings.
IEC 60502 / IEC TR 62095 / IEC 60287 / IEC 60364-5-52	Code of practice for installation and maintenance of power cables up to and including 33 kV rating.
ISO 10684	Technical supply conditions for threaded steel fasteners (hot-dip galvanized coatings on threaded fasteners).
IEC 60529	Degrees of protection provided by enclosures (IP Code) for low-voltage switchgear and controlgear.
IEC 62305	Code of practice for the protection of buildings and allied structures against lightning.
ISO 1461	Recommended practice for hot-dip galvanizing of iron and steel.
ISO 1461	Method for testing the uniformity of coating on zinc-coated articles.
IEC 60364-5-54 / IEC 60364-5	Code of practice for earthing.

ISO 2009	Fasteners — Single-coil rectangular-section spring washers.
ISO 1460	Methods for determination of mass of zinc coating on zinc-coated iron and steel articles.
IEC 60811	Compression-type tubular in-line connectors for aluminium conductors of insulated cables.
IEC 60889	Compression-type tubular terminal ends for aluminium conductors of insulated cables.
IEC 61386	Conduit systems for cable management in electrical installations.
ISO 15614	Metal-arc welding of carbon and carbon-manganese steels — Recommendations.
IEC 60227 / IEC 60245	Joints and terminations for polymeric cables for working voltages from 6.6 kV up to and including 33 kV — Performance requirements and type tests.
ISO 1182 / ISO 5658 / ISO 834	Fire tests on building materials and structures.
IEEE 80	IEEE Guide for Safety in AC Substation Grounding.
IEEE 142	Grounding of Industrial and Commercial Power Systems.
DIN 46267 (Part II)	Non-tension-proof compression joints for aluminium conductors.
DIN 46329	Cable lugs for compression connections, ring type, for aluminium conductors.
VDE 0278	Tests on cable terminations and straight-through joints.
IEC 62444	Cable glands for electrical installations — Specification for mechanical cable glands for elastomeric and plastic insulated cables.

Equipment complying with other internationally accepted standards such as IEC, BS, DIN, USA, VDE, NEMA etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official

amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.

10.6.2 DESIGN AND CONSTRUCTIONAL FEATURE

Inter Plant Cabling

Interplant cabling for main routes shall be laid in Cable trenches/cable trays/buried/duct banks. In case of Duct banks, pull-pits shall be filled with sand and provided with a PCC covering. All buried cables shall be of armoured type. overground cabling methodology may also be adopted as per site condition if underground is not feasible (e.g. on RCC/concrete pedestals etc.). In such cases, the cables shall be UV-resistant supported by test reports.

Cable Sizing Conditions

All cables shall be suitably derated as per the laying conditions for carrying the required load current and fault current. For derating, the ambient temperature for directly buried cables shall be taken as 40° C and 50° C for cables laid in air.

All XLPE cables shall be rated at 90° C conductor temperature for AC Voltage drop calculation and 80° C for DC Voltage calculation. However, for Voltage drop calculation in DC Cable, actual conductor temperature as per loading can be used.

Trenches

PCC flooring of built up trenches shall be sloped for effective drainage with sump pits and sump pumps.

10.7 General

The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling.

Sizing criteria, derating factors for the cables shall be met as per respective chapters. However, for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminum conductor and 2.5 sq.mm. for copper conductor cable.

Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to:

- Meet all safety requirements
- Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/interferences, etc.

10.8 EQUIPMENT DESCRIPTION

10.8.1 Cable trays, Fittings & Accessories

Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.

Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant IS.

Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm.

Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanised as per relevant IEC/ISO. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm

10.8.2 Support System for Cable Trays

Cable tray support system shall be pre-fabricated similar or equivalent to "Unistrut make".

Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types : (i) C1:- having provision of supporting cable trays on one side and (ii) C2:-having provision of supporting cable trays on both sides. The support system shall be the type described hereunder:

Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardware's such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.

The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardwares fittings and accessories shall be prefabricated factory galvanized.

The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvanized surface shall be brushed and red lead primer, oil primer & aluminium paint shall be applied

All steel components, accessories, fittings and hardware shall be hot dip galvanized after completing welding, cutting, drilling and other machining operation.

Support system shall be able to withstand

- weight of the cable trays
- weight of the cables (75 Kg/Meter run of each cable tray)
- Concentrated load of 75 Kg between every support span.
- Factor of safety of minimum 1.5 shall be considered.

10.8.3 Pipes, Fittings & Accessories

Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria

GI Pipes shall be of medium duty as per EN 10255/ ISO 49

Duct banks shall be High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes.

Hume pipes shall be NP3 type as per ASTM C76/ EN1916

10.8.4 Junction Boxes

Junction Boxes with IP:55 degree of protection, shall comprise of a case with hinged door constructed from cold rolled sheet steel of thickness 2mm. Top of the boxes shall

be arranged to slope towards rear of the box. Gland plate shall be 3mm thick sheet steel with neoprene/synthetic rubber gaskets. All junction boxes shall be of adequate strength and rigidity, hot dip galvanized as per relevant IS, and suitable for mounting on wall, columns, structures etc. The boxes shall include brackets, bolts, nuts, screws M8 earthing stud etc. required for installation.

Terminal blocks shall be 1100V grade, 10Amps rated, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals the screw shall be captive, preferably with screw locking design. All terminal blocks shall be suitable for terminating on each side two (2) nos. stranded copper conductors of size upto 2.5 sq mm each. All internal wiring shall be of minimum 1.5 sq. mm cu. Conductor PVC wire.

10.8.5 Terminations & Straight through Joints

Termination and jointing kits for 33kV, 11kV, 6.6 kV and 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be pre-moulded type, taped type or heat shrinkable type. 33kV, 11kV and 6.6 kV grade joints and terminations shall be type tested as per IEC 60502/IEC 60228/IEC 60811. 3.3kV grade joints and terminations shall be type tested as per VDE0278. Critical components used in cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the aluminium solderless crimping type cable lugs & ferrule as per DIN standard

Straight through joint and termination shall be capable of withstanding the fault level for the system.

1.1 KV grade Straight Through Joint shall be of proven design.

10.8.6 Cable glands

Cable shall be terminated using double compression type cable glands. Cable glands shall conform to BS:6121 and be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation. Cable glands shall be made of heavy duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 micron. All washers and hardware shall also be made of brass with nickel chrome plating Rubber components shall be of

neoprene or better synthetic material and of tested quality. Cable glands shall be suitable for the sizes of cable supplied/erected.

10.8.7 Cable lugs/ferrules

Cable lugs/ferrules for power cables shall be tinned copper solderless crimping type suitable for aluminium compacted conductor cables. Cable lugs and ferrules for control cables shall be tinned copper type. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of terminals provided on the equipment. Cable lugs and ferrule shall conform to relevant standard

10.8.8 Trefoil clamps

Trefoil clamps for single core cables shall be pressure die cast aluminum or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength to withstand the forces generated by the peak value of maximum system short circuit current.

10.8.9 Cable Clamps & Straps

The cable clamps required to clamp multicore cables on vertical run shall be made up of Aluminium strip of 25x3 mm size. For clamping the multicore cables, self-locking, de-interlocking type nylon clamps/straps shall be used. The clamps/straps shall have sufficient strength and shall not get affected by direct exposure to sun rays and outdoor environment.

10.8.10 Receptacles

Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped galvanized or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/column/structure, gland plate etc. The ON-OFF switch shall be rotary type heavy duty, double break,AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polymide 6.6 grade with adequate current rating

and size. The welding receptacles shall be provided with inbuilt ELCB rated for suitable mA sensitivity.

10.9 Galvanizing

Galvanizing of steel components and accessories shall conform ISO 1460 / ISO 1461. Additionally galvanizing shall be uniform, clean smooth, continuous and free from acid spots.

The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per ISO 898/ ISO10684/ ISO 4042 . The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified

10.10 Welding

The welding shall be carried out in accordance with AWS D1.1/ ISO15614. All welding procedures and welders qualification shall also be followed strictly in line with IS:9595

10.11 INSTALLATION

10.11.1 Cable tray and Support System Installation

Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures.

Horizontally running cable trays shall be clamped by bolting to cantilever arms and vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both top and bottom side rails at an interval of 2000 mm in general. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000mm in general. Fixing of cable trays to cantilever arms or main support channel by welding shall not be accepted. Cable tray installation shall generally be carried out as per the approved guidelines/ drawings. Vendor shall design the support system along with tray, spacing etc in line with relevant standard.

The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated.

The contractor shall fix the brackets/ clamps/ insert plates using anchor fasteners. Minimum size of anchor fasteners shall be M 8 X 50 and material shall be stainless steel grade 316 or better. Anchor fastener shall be fixed as recommended by

manufacturer and as approved by site engineer. For brick wall suitable anchor fasteners shall be used as per the recommendations of manufacturer. Make of anchor fasteners subject to QA approval.

All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75 mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor.

In certain cases it may be necessary to site fabricate portions of trays, supports and other non standard bends where the normal prefabricated trays, supports and accessories may not be suitable. Fabricated sections of trays, supports and accessories to make the installation complete at site shall be neat in appearance and shall match with the prefabricated sections in the dimensions. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint.

10.11.2 Conduits/Pipes/Ducts Installation

The Contractor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in the floor/ roof/ wall/ cable tunnel/ cable trenches made for conduit installation shall be sealed and made water proof by the Contractor either with any proven fire sealing system rated for one hour or Modular multi-diameter cable sealing system consisting of frames, blocks, Compression wedge and its accessories. The Cable sealing system should have been tested for fire insulation for min. 1 hr as per BS 476 and shall also provide water sealing. System shall be anti- rodent and anti- termite.

GI pull wire of adequate size shall be laid in all conduits before installation. Metallic conduit runs at termination shall have two lock nuts wherever required for junction boxes etc.

Conduit runs/sleeves shall be provided with PVC bushings having round edge at each end. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed with Glass wool/Cement Mortar/Putty to prevent entrance of moisture and foreign material.

Exposed conduit/pipe shall be adequately supported by racks, clamps, straps or by other approved means. Conduits /pipe support shall be installed square and true to

line and grade with an average spacing between the supports as given below, unless specified otherwise

Conduit / Pipe Size (Diameter)	Maximum Support Spacing
Up to 40 mm	1.0 m
50 mm	2.0 m
65 mm to 85 mm	2.5 m
100 mm and above	3.0 m

For bending of conduits, bending machine shall be arranged at site by the contractor to facilitate cold bending. The bends formed shall be smooth.

10.11.3 Junction Boxes Installation

Junction boxes shall be mounted at a height of 1200mm above floor level or as specified in the drawings and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/ expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.

10.11.4 Cable Installation

Cable installation shall be carried out as per IEC 60364-5-52IEC 60364-5--52 and other applicable standards.

For Cable unloading, pulling etc. following guidelines shall be followed in general:

- Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.

- While laying cable, ground rollers shall be used at every 2 meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer. Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.

Cables shall be laid on cable trays strictly in line with cable schedule

Power and control cables shall be laid on separate tiers in line with approved guidelines/drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, H.T. cables shall be laid on topmost tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil center lines and clamped at every two meter. All multi core cables shall be laid in touching formation. Power and control cables shall be secured fixed to trays/support with self-locking type nylon cable straps with de-interlocking facilities. For horizontal trays arrangements, multi core power cables and control cables shall be secured at every five meter interval. For vertical tray arrangement, individual multi core power cables and control cables shall be secured at every one meter by nylon cable strap. After completion of cable laying work in the particular vertical tray, all the control cables shall be binded to trays/supports by aluminium strips at every five meter interval and at every bend.

Bending radii for cables shall be as per manufacturer's recommendations and IEC 60364-5-52.

Where cables cross roads/rail tracks, the cables shall be laid in hume pipe/ HDPE pipe.

No joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment in main plant area shall not be permitted. Vendor shall identify and accordingly procure the cable drum length.

In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so

that shifting of termination in terminal blocks can be done without requiring any splicing.

Wherever few cables are branching out from main trunk route troughs shall be used.

Wind loading shall be considered for designing support as well Cable trays wherever required.

Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures.

The installation work shall be carried out in a neat workman like manner & areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day. Contractor shall replace RCC/Steel trench covers after the Installation work in that particular area is completed or when further work is not likely to be taken up for some time.

10.11.5 Separation

At least 300mm clearance shall be provided between:

- HT power & LT power cables,
- LT power & LT control/instrumentation cables,

Minimum number of spare cores required to be left for interconnection in control cables shall be as follows:

No. of Cores in Cable	No. of Spare Cores
2C, 3C	Nil
5C	1
7C - 10C	2
14C and above	3

Directly Buried Cables

Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting, supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IEC 60364-5-52.

RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.

Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 20 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminum with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Contractor may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags

While crossing the floors, unarmoured cables shall be protected in conduits upto a height of 500 mm from floor level if not laid in tray.

10.11.6 Cable Terminations & Connections

The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer'' instructions, drawings and/or as directed by Project Manager. Cable jointer shall be qualified to carryout satisfactory cable jointing/termination. Contractor shall furnish for review documentary evidence/experience reports of the jointers to be deployed at site.

Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job to the satisfaction of the Project Manager.

The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for punching of gland plates, painting and touching up. Holes shall not be made by gas cutting. The holes

shall be true in shape. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminium sheets.

Control cable cores entering control panel/switchgear/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with self-locking type nylon cable ties with de interlocking facility to keep them in position.

All the cores of the control cable to be terminated shall have identification by providing ferrules at either end of the core, each ferrule shall be indelible, printed single tube ferrule and shall include the complete wire number and TB number as per the drawings. The ferrule shall fit tightly on the core. Spare cores shall have similar ferrules with suffix sp1, sp2, ---etc along with cable numbers and coiled up after end sealing.

All cable terminations shall be appropriately tightened to ensure secure and reliable connections

11. ENERGY MANAGEMENT SYSTEM AND SCADA

11.1 GENERAL

1. Energy Management System (EMS) system required for real time monitoring, operation, control, reliable & efficient operation and optimization of performance of the Solar+BESS Plant. SCADA system shall be part of EMS system. EMS shall be able to acquire real time data of various equipment of Solar+BESS system, have in built logic/programming to monitor, control, and optimize the performance of Project as per specification.
2. Suitable provision Remote control and monitoring facility EMS should be provided in addition to local control and monitoring so that all trouble-shooting and subsequent action can be taken from EFL NCC. Necessary software at remote and local end shall be under scope of Bidder.
3. Contractor shall provide complete EMS system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation of entire solar+ BESS Plant and its auxiliary systems. Contractor shall include in his proposal all the Industrial Grade Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cable etc. needed for the completeness even if the same are not specifically appearing in these specifications.
4. EMS system includes the supply and integration of redundant Power Quality Meters at suitable points. Interconnection with optical fiber communication cables through IEC 61850 to EMS shall also be in Bidder's scope. Also Supply of necessary switches at HT switchgear and communication cable from EMS to individual numerical relays and its integration with required accessories is under Bidder's scope.
5. Remote control of all the HT Breakers either in hard or soft signal.
6. Remote control of PCS & Solar Inverter active and reactive power as per requirement.
7. SCADA shall also be able to acquire, display and store real time data, status and alarm signal from following equipment included but not limited to as required or offered under the scope of this specification:
   - Battery containers with Aux system and BMS
   - All the HT Switchgear
   - Inverter duty Transformers
   - Incomer and bus coupler breaker of LT Panel.
   - Power conditioning System (PCS) & Solar Inverter
   - UPS and Battery charger as per requirement/ Auxiliary supply systems

- TEM/ABT/MFM meter, numerical relay, fire alarm panel, GPS time synchronization unit and Aux. transformers.
- SCADA Hardware, Accessories and Communication link
- Any other equipment required to complete monitoring of Solar+BESS plant upto 33kV level.

8. Display the status of major electrical equipment using a Single-Line Diagram (SLD) or Mimic Diagram. The Mimic Diagram shall follow the standard colour coding guidelines for electrical systems.
9. Display and storage of derived/calculated/integrated values.
10. Generate, store and retrieve user configurable periodic reports. EMS/SCADA shall have facility to generate report in MS Excel file type.
11. Remote monitoring of essential parameters of plant on the web using popular web browser without requirement of additional software. Same shall be authorised with user id and password using standard modem. User ID and password for remote view can only be changed by EMS/SCADA Administrator. Internet connection for transferring data to web shall be taken by Contractor in the name of EFL Site for O & M period.
12. Self-monitoring and diagnostic functions.
13. The contractor shall provide at least one GPS clock a Plant, which shall be synchronized with the SCADA/EMS system. All devices having real-time clock (RTC) with time synchronization facility and are communicating with BESS EMS/SCADA shall be synchronized with GPS Clock through SCADA or directly with GPS Clock. The technical details of GPS have been specified elsewhere in the specification
14. Type of signal from equipment (Hard wired or Soft) shall be as per specification of the equipment mentioned in the respective chapter and approved during detail engineering.
15. SCADA shall provide real time performance monitoring according to IEC 61724 standard. In case of conflict between this specification and those (AS/NZ codes, standards, etc.) referred to herein, the former shall prevail.
16. The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is affected. Control system shall be designed to prevent abnormal swings due to loss of Control System power supply, failure of any Control System component, open circuit/short circuit. On any of these failures the controlled equipment/parameter shall either remain in last position before failure or shall come to fully open/close or on/off state as required for the safety of plant/personnel/equipment and as finalized during detailed engineering. System shall be designed such that there will be no upset when power is restored. These

operation shall be demonstrated by vendor during Factory Accepted Test (FAT) in the presence of EFL Representative.

17. All the power supply module, Ethernet switches and network accessories for non-air conditioned area shall be suitable for operating in ambient temperature of 50 Deg C minimum.
18. Power plant controller (PPC) shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working PPC processor, there shall be an appropriate alarm and simultaneously the hot standby PPC processor shall take over the plant control function automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. It shall be possible to keep any of the PPC processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor. The Solar+BESS plant SCADA and PPC networks shall be suitably designed, so that PPC shall directly and independently able to control the individual PCS & Solar inverter. Detailed control logic in the PPC shall be finalized during detailed engineering stage as per grid requirement to support voltage and frequency with suitable droop characteristic as per Australian and New Zealand standard.

Performance Monitoring

As part of the performance monitoring, the following shall be carried out:

1. The Contractor must install necessary equipment to continuously measure Solar & BESS operating parameters (including but not limited to voltage, current, ambient conditions etc.) as well as energy input into and energy output from the BESS along with Metering arrangement in accordance with extant regulations.
2. The plant SCADA should be OPC version 2.0a (or a later version including OPC UA) compliant and implement appropriate OPC-DA server as per the specification of OPC Foundation. This time series data shall be available from the Project SCADA system to facilitate monitoring and should include among others as stated before, below parameters to facilitate daily, monthly and annual Report for performance monitoring.
3. Web-based monitoring should be available, which should not be machine dependent. The web-based monitoring should provide the same screens as available in the plant. Also, it should be possible to download reports from a remote web-client in PDF or Excel format.

11.2 SCADA CONTROLLER SYSTEM:

The redundant controller of SCADA/EMS/PPC at control room shall be of PLC/DCS based as per specification given hereunder. For other locations such as Inverter/Battery containers Room, PLC/ IO modules/RTUs are acceptable.

11.2.1 Main control room SCADA shall have the following feature:

Facility for implementation of all logic functions for control, protection and annunciation of the equipment and systems.

Main control room SCADA shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working processor, there shall be an appropriate alarm and simultaneously the hot standby processor shall take over the complete plant operation automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. In the event of both processors failing, the system shall revert to fail safe mode. It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.

The memory shall be field expandable. The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future. Programmed operating sequences and criteria shall be stored in nonvolatile semiconductor memories like EPROM. All dynamic memories shall be provided with buffer battery backup for at least 360 hours. The batteries shall be lithium or Ni-Cd type.

A forcing facility shall be provided for changing the states of inputs and outputs, timers and flags to facilitate fault finding and other testing requirements. It shall be possible to display the signal flow during operation of the program.

11.2.2 DATA COMMUNICATION SYSTEM (DCS)

The Data Communication System shall include a redundant Main System Bus with hot back-up. Other applicable bus systems like cubicle bus, local bus, I/O bus etc shall be redundant except for backplane buses which can be non-redundant.

The DCS shall have the following minimum features:

i. Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLCs and between PLCs and operator work station.

ii. The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.

iii. If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility.

iv. Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility (ECC) shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus shall be automatic and completely bump less and the same shall be suitably alarmed/logged.

v. The design and installation of the system bus shall take care of the environmental conditions as applicable.

vi. Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 25% spare capacity shall be available for future expansion

vii. Cat 6 UTP or fiber optic cables shall be employed.

viii. The Contractor shall furnish details regarding the communication system like communication protocol, bus utilization calculations etc.

ix. Contractor shall setup Gigabit Ethernet based Plant Local Area Network (LAN) to connect to different communication nodes at Inverter /Switchgear location etc. with redundant backbone using ring or better topology. Each Modbus cable shall be provided with Surge protection device at SCADA Panel End. Specification of OFC and Modbus cable has been given elsewhere in this specification.

x. Provision of monitoring and event data via the communication interface shall adhere to DNP3 AN2011-001 / IEC 61850 to the extent possible and capture at least the following data points:

- Frequency at the AC bus
- AC real power
- Power factor
- Real energy delivered
- Real energy received
- Auxiliary power
- Auxiliary energy
- DC power
- DC voltage
- DC current

- Phase A voltage
- Phase A angle
- Phase B voltage
- Phase B angle
- Phase C voltage
- Phase C angle
- Battery state of charge
- Battery string currents
- Battery temperature

xi. The DAS shall provide unsolicited message capability for reporting critical alarms. The Contractor and the Employer will agree on a list of alarms that are reported the instant they are detected. However, a minimum of following parameters shall be displayed on BESS local control panel, console, or SCADA computer:

- Main temperature Alarm (on system temperature exceeding a predetermined threshold)
- Smoke/fire Alarm (on system detection of smoke/fire)
- DC leakage current (battery leakage current to ground exceeding a predetermined threshold)
- Breaker status (connect/disconnect switch)
- AC voltage OK (system ac voltage exceeding a predetermined threshold)
- Battery temperature alarm (battery temperature exceeding a predetermined threshold)
- Synchronization error shutdown
- PCS fault
- Weak Unit Battery Alarm
- AC system fault
- Control logic problem (problem with the BESS control logic)
- DC fuse blown
- Container door open (BESS container door opening)

11.3 HUMAN MACHINE INTERFACE SYSTEM (HMIS)

1. HMIS configured around latest state-of-the art servers/Workstations with open architecture supporting OPC /TCP/IP protocols, etc.
2. The SCADA shall be OPC version 2.05a compliant and implement a OPC - UA server as per the specification of OPC Foundation. All data should be accessible through this OPC server.

3. For communicating the generation data of plant in EFL, the SCADA system shall be interfaced/ connected with PI server of EFL on OPC Protocol. The details of EFL PI server shall be furnished during the detailed engineering.
4. Graphical Interface Unit (GIU) / Operator workstation (OWS) shall perform control, monitoring and operation (as applicable) for plant equipment's connected with SCADA system.
5. Engineering workstation (EWS) shall work as a programming station both for controller and SCADA. It shall be possible to use same EWS as programming station and the Human Machine Interface System.
6. SCADA System shall be provided with redundant OWS. Operator shall be able to access all control/information related data under all operating conditions including a single processor and computer failure/hardware failure at Control room in the HMIS.
7. In addition to a desktop based EWS, vendor shall also provide dedicated portable (laptop) based EWS.
8. All frequently called important functions including major displays shall be assigned to dedicated function keys on a soft keyboard for the convenience of the operator for quick access to displays & other operator functions.
9. The mimic shall be configured on the HMI and it shall be possible to control, monitor and operate the plant from the same.
10. The SCADA System shall have ability to perform operator functions for each OWS / GIU as a minimum, include Control System operation (A/M selection, raise/lower, set point/bias change, on/off, open/close operation, mode/device selection, bypassing criteria, sequence auto, start/stop selection, drive auto selection, local-remote/other multi-position selection etc.); alarm acknowledge; call all kind of displays, logs, summaries, calculation results, etc.; printing of logs & reports; retrieval of historical data; and any other functions required for smooth operation, control & management of information as finalized during detailed engineering.
11. The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
12. The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
13. The system shall have built-in safety features that will allow/disallow certain functions and entry fields within a function to be under password control to protect

against inadvertent and unauthorized use of these functions. Assignment of allowable functions and entry fields shall be on the basis of user profile. The system security shall contain various user levels with specific rights as finalized by the Employer during detailed engineering. However, no. of user levels, no. of users in a level and rights for each level shall be changeable by the programmer (Administrator).

14. Wherever Graphical Interface Unit is envisaged, it shall meet the minimum functional requirements of monitoring, operating & controlling the process and displaying information related to process locally. GIU shall be provided with TFT active matrix or LED display and keypad for operation. GIU shall be ruggedly designed to withstand hard environments like high temperature, shock and vibration.
15. Bidder has to provide suitable hardware DMZ network firewall to restrict unauthorized access to HMI/ SCADA system. Details specification of hardware firewall is provided elsewhere in the specification.
16. SCADA shall have facility to provide real time reporting of alarms and statistical data through SMS and e-mails.
17. Programming of the PLC Processor/controller as well as programming of HMIS shall be user friendly with graphical user interface and shall not require knowledge of any specialized language.
18. The programming of HMIS (like development and modification of data base, mimics, logs / reports, HSR functionalities etc.) shall also be possible through user-friendly menus etc.
19. All programming functionalities shall be password protected to avoid unauthorized modification.

PROGRAMMING FUNCTIONALITIES

Programming of the PLC Processor/controller as well as programming of HMIS shall be user friendly with graphical user interface and shall not require knowledge of any specialized language. For example, the programming of PLC shall use either of the following:

- Flow-chart or block logic representing the instructions graphically
- Ladder diagrams

The programming of HMIS (like development and modification of data base, mimics, logs / reports, HSR functionalities etc.) shall also be possible through user-friendly menus etc.

All programming functionalities shall be password protected to avoid unauthorized modification.

11.4 SOFTWARE REQUIREMENT

All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirement shall be provided. The programs shall include high level languages as far as possible. The contractor shall provide sufficient documentation and program listing so that it is possible for the Employer to carry out modification at a later date.

The Contractor shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.

Industry standard operating system like WINDOWS (latest version) etc. to ensure openness and connectivity with other system in industry.

SCADA system shall include the following standard protocols as a minimum:

- Modbus (TCP/IP, RTU, ASCII).
- Sub Station Protocol (IEC-61850 and IEC 60870 -5-101/104).

Any other protocol on which the offered equipment (by Contractor) will communicate with SCADA

The system shall have user friendly programming language & graphic user interface.

All system related software including Real Time Operating System, File management software, screen editor, database management software, On line diagnostics/debug software, peripheral drivers software and latest versions of standard PC-based software, Antivirus software and latest WINDOWS based packages (MS Word, Excel and PowerPoint) etc. and any other standard language offered shall be furnished as a minimum.

All application software for SCADA system functioning like input scanning, acquisition, conditioning processing, control and communication and software for operator interface of monitors, displays, trends, curves, bar charts etc. Historical storage and retrieval utility, and alarm functions shall be provided.

The Contractor shall provide software locks and passwords to Employer's engineers at site for all operating & application software so that Employer's engineers can take backup of these software and are able to do modifications at site.

The Contractor shall provide software license for all software being used in Contractor's System. The software licenses shall be provided for the project (e.g. organization or site license) and shall not be hardware/machine specific. That is, if any hardware/machine is upgraded or changed, the same license shall hold good, and it shall not be necessary for Employer to seek a new license/renew license due to up gradation/change of hardware/machine in Contractor's System at site. All licenses shall be valid for the continuous service life of the plant.

All the SCADA Software with license Key shall be handed over to EFL on the SSD (Solid State Drive) media. All the hardware and software shall be licensed to EFL.

11.5 PARAMETRIC REQUIREMENTS

The control system shall be designed such that under worst case loading conditions the response time shall not be worse than the following:

i. On/Off Command: - The response time for screen update after the execution of the control command from the time the command is issued shall be one second (excluding the drive actuation time).
ii. Adjustment Command: - 0.5 to 1 second.
iii. On screen Updating and All Control related displays:- 1 second.

Bar Chart displays, Plant Mimic displays, Group review displays, X-T Plot Displays and Plant Summary Displays: 1 to 2 seconds.

All the Analog data shall be scanned at the resolution of 1(one) second and refreshed on screen however, recording of data shall be as finalized during detail engineering.

11.6 INPUT/OUTPUT MODULES

The SCADA system should be designed according to the location of the input/output cabinets as specified.

Input Output modules, as required in the Control System for all type of field input signals (4-20 mA, non-changeover/change over type of contact inputs etc.) and outputs from the control system (non changeover/change over type of contact, output signals for energizing interface relays at suitable DC voltage as decided during detail engineering, 4-20 mA output etc.) are to be provided by the Contractor.

Electrical isolation of 1.5kV with optical couplers between the plant input/output and controller shall be provided on the I/O cards. The isolation shall ensure that any

inadvertent voltage or voltage spikes (as may be encountered in a plant of this nature) shall not damage or mal- operate the internal processing equipment.

The Input/output system shall facilitate modular expansion in fixed stages. The individual input/output cards shall incorporate indications on the module front panels for displaying individual signal status.

Individually fused output circuits with the blower fuse indicator shall be provided. All input/output points shall be provided with status indicator.

The I/O Module shall have the following features:

a. Power supply monitoring
b. Contact bounce filtering
c. Optical isolation between input and output signals with the internal circuits.
d. In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode. The fail-safe mode shall be finalized during detailed engineering.

Binary Output modules shall be rated to switch ON/OFF coupling relays of approx. 3 VA. Analog output modules shall be able to drive a load impedance of 500 Ohms minimum.

Electrical isolation of 1.5kV with optical couplers between the plant input/output and controller shall be provided on the I/O cards. The isolation shall ensure that any inadvertent voltage or voltage spikes (as may be encountered in a plant of this nature) shall not damage or mal- operate the internal processing equipment.

Requirement of Nos. of channel in each type of Module (Analog Input, Analog Output, Binary Input, Binary Output, RTD) and Modbus link at Inverter and main control room shall be calculated based on the Input/output signal list to be submitted by the contractor for approval during detail engineering

11.7 SYSTEM SPARE CAPACITY

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

i. 10 % spare channels in input/output modules fully wired up to cabinets TB.

ii. Wired-in "usable" space for 10% modules in each of the system cabinets for mounting electronic modules wired up to corresponding spare terminals in system cabinets.

iii. Empty slots between individual modules/group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of Contractor shall not be considered as wired-in "usable" space for I/O modules.

iv. Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 10 % blank space.

v. Each processor / controller shall have 20% spare functional capacity to implement additional function blocks, over and above implemented logic/ loops. Further, each processor / controller shall have spare capacity to handle minimum 20% additional inputs/ outputs of each type including above specified spare requirements, over and above implemented capacity. Each of the corresponding communication controllers shall also have same spare capacity as that of processor/controller.

vi. The Data communication system shall have the capacity to handle the additions mentioned above.

vii. Ten (10) percent spare relays of each type and rating mounted and wired in cabinets TB. All contacts of relays shall be terminated in terminal blocks of cabinets.

viii. The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time / duty cycle, etc. from those stipulated under this specification.

11.8 OPERATOR INTERFACE DISPLAYS/LOGS/REPORTS

Suitable Operator Interface Displays/Logs/Reports for control operation & monitoring shall be provided. The details shall be finalized during detailed Engineering stage.

Minimum quantities shall be as follows: -

i. Various displays on the OWS shall as a minimum include P&ID displays or mimic, bar chart displays, X-Y & X-T plot (trend) displays, operator guidance message displays, group displays, plant start-up/shutdown message displays, system status displays etc. Number of displays and the exact functionality shall be on as required basis and as finalized during detailed engineering subject to the minimum quantities as given in subsequent clauses. For X-T & X-Y plots, the

facility of providing a background grid on operator request shall be variable with adequate no. of divisions in both co-ordinates.

ii. The minimum quantity of major types of displays per unit shall be as follows:

Sl	Display	Minimum Qty for Plant capacity of 50 MW or Less	Additional Qty for each 10 MW or part above 50 MW
a)	Control displays (group/sub- group/ sequence/loop)	(On as reqd. basis subject to 100 minimum)	**(On as reqd. basis subject to 100 minimum)**
b)	P&ID/ mimic display	25	**5**
c)	X-Y Plot (with superimposed operating curves + using user selectable stored data)	25+25	**5+5**
d)	Group displays	30	**5**
e)	Operator guidance message: 20	**NIL**	
f)	**System status & other diagnostic display**	**on as required basis**	**on as required basis**

The assignment for the above will be done by the contractor as per the requirement of operation of contractor's system as well as for maintenance. The balance displays shall be left as spare for future modification/addition.

11.9 HISTORICAL STORAGE AND RETRIEVAL SYSTEM (HSRS)

i. The HSRS shall collect, store and process system data from MMIPIS data base. The data shall be saved online on hard disk and automatically transferred to non-erasable long term storage media once in every 30 Days periodically for long term storage. Provision shall be made to notify the operator when hard disk is certain percentage full.

ii. The data to be stored in the above system shall include alarm and event list, periodic plant data, selected logs/reports.

iii. iii) The system shall provide user-friendly operator functions to retrieve the data from historical storage. It shall be possible to retrieve the selected data on OWS in form of trend/report by specifying date, time & period. Further, suitable index files/directories shall also be provided to facilitate the same.

iv. iv) In addition to above, the system shall also have facility to store & retrieve important plant data for a very long duration on portable external long term storage media. Bidder shall provide two numbers of portable external hard drive of 2TB each.

v. For long term plant performance analysis, the following plant data as a minimum with time stamping and interval as indicated in below table but not limited to shall be stored daily on historian.

Important plant data for a very long duration (plant life) Storage on Historian:

Sl.	Parameter	Time Interval
1	Power Conditioning System (PCSs):- DC Voltage, DC Power, DC Current,, AC Active & Reactive Power, Power factor, AC Current & Voltage, Energy, PCS room temp, PCS Cabinet temp and Modules Temp	1 (One) Minute
2	MFM, Energy meter and Numerical Relay data:- Active & Reactive Power, Energy (day), Current and Voltage	1 (One) Minute

3	Export feeder/s Energy Meter Data:- Active & Reactive Power, Energy import and export, Current and Voltage and Grid Frequency.	1 (One) Minute
4	Daily energy export from each PCS	24 (Twenty Four) Hours
5	Total sum of daily energy export from all PCS	24 (Twenty Four) Hours
6	BESS Parameter for different application function assessment: Active & Reactive Power for solar feeders, grid feeders, BESS feeders (33kV level) SPV 30Minutes moving average value. Reference Target Active & Reactive power	1(one) second
7	BESS Battery Voltage, SOC (upto Module and String level) and other Important Battery and BMS data.	1(one) second

11.10 SCADA PANEL/CABINET/CONTROL DESK/FURNITURE

The SCADA cabinets shall be IP-42 protection class.

The Contractor shall ensure that the packaging density of equipment in these cabinets is not excessive and abnormal temperature rise, above the cabinet temperature during normal operation or air-conditioning failure, is prevented by careful design. The Contractor shall ensure that the temperature rise is limited to 10 deg. C above ambient and is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets. Ventilation blowers shall be furnished as required by the equipment design and shall be sound proof to the maximum feasible extent. If blowers are required for satisfactory system operation,

dual blowers with blower failure alarm shall be provided in each cabinet with proper. Suitable louvers with wire mesh shall be provided on the cabinet.

The cabinets shall be designed for front access to system modules and rear access to wiring and shall be designed for bottom entry of the cables for Main control room.

The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications, preferred height of the cabinet shall not higher than 2200mm. The cabinets shall be equipped with full height front and rear doors. The floor mounting arrangement for other cabinets shall be as required by the Employer and shall be furnished by the Contractor during detailed engineering. Wall mounted cabinet is acceptable for Inverter room/sub- pooling switchgear.

Cabinet doors shall be hinged and shall have turned back edges and additional braking where required ensuring rigidity. Hinges shall be of concealed type. Door latches shall be of three-point type to assure tight closing. Detachable lifting eyes or angles shall be furnished at the top of each separately shipped section and all necessary provisions shall be made to facilitate handling without damage. Front and rear doors shall be provided with locking arrangements with a master key for all cabinets. If width of a cabinet is more than 800 mm, double doors shall be provided.

Two spray coats of inhibitive epoxy primer-surface shall be applied to all exterior and interior surfaces. A minimum of 2 spray coats of final finish colour shall be applied to all surfaces. The final finished thickness of paint film on steel shall not be less than 65-75 micron for sheet thickness of 2 mm and 50 microns for sheet thickness of 1.6 mm. The Preferable finish colors for exterior and interior surfaces shall conform to following shades:

Exterior: - As per RAL 9002 (End panel sides RAL 5012),

Interior: - Same as above

Paint films which show sags, checks or other imperfections shall not be acceptable.

As an alternative, single coat of anodic dipcoat primer along with single textured powder coating with epoxy polyester meeting the thickness requirement is also acceptable.

Control desk shall be free standing table top type with doors at the back and shall be constructed of 2 mm thick CRCA steel plates. A 19 mm thick wooden top shall be

provided on the desk to keep the monitors at top and computers inside. Control desk shall consist of vertical, horizontal and base supports with their coverings for work surface, keyboard trays, mouse pads, monitor shelf and concealed cable and wire way management, perforated trays with covers in both horizontal and vertical directions. ASCII Keyboard shall be capable of being pulled out through a tray.

Contractor shall provide the two power supply feeders (DC supply or UPS AC) and one raw supply feeder of suitable rating to cater all the load requirements of SCADA panel/cabinet/control desk. System remain in service in case of single power supply failure/power supply module failure. Suitable alarm shall be generated in case of any power supply failure.

The cabling / wiring between OWS & CPU'S, power supply cables etc. shall be aesthetically routed and concealed from view.

Chairs – Industry standard revolving chairs with wheels and with provision for adjustment of height (hydraulically/gas lift) shall be provided for the operators and other personnel in control room area. These shall be designed for sitting for long duration such that these are comfortable for the back. Arm-rests in one piece shall be of poly-urethane and twin wheel castor of glass filled nylon.

One Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer.

All the furniture shall be of reputed make (Godrej or Equivalent).

HMIPIS HARDWARE

The HMIPIS as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.

The Workstation/Servers employed for HMIPIS implementation shall be redundant based on industry standard hardware and software which will ensure easy connectivity with other systems and portability of Employer developed and third party software.

Redundant sets of communication controllers shall be provided to handle all the communication between the HMIPIS and redundant system bus and to ensure specified system response time and parametric requirements. Each communication controller shall have message checking facility. Power Fail Auto Restart (PFAR) facility with automatic time update shall be provided.

All the peripherals shall conform to the following minimum requirement but the exact make & model shall be as approved by Employer during detailed engineering. The LAN to be provided under HMIPIS shall support TCP/IP protocol (Ethernet connectivity) with OPC RDI for interface with PLCs/other systems and shall have data communication speed of min. 100 MBPS. All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.

Engineering Workstations/ Operator Workstations/ Historian/ Portable EWS

Sl No.	Features	Industrial Grade Engineering Cum Operator Workstations/ Operator workstations/ Other workstations/ Documentation station
1.	Processor	Engineering Cum Operator Workstations: 64 bit Server Grade (Xeon or Equivalent or better), Octacore minimum For other Workstation: 64 bit (i7 or Equivalent or better)
2.	Memory	Engineering Cum Operator Workstations: 16 GB RAM upgradable to 24 GB minimum For other Workstation: 8 GB RAM upgradable to 16 GB
3.	Hard Disk	Engineering Cum Operator Workstations: 1 TB RAID1 For Historian: 1 TB ultra wide RAID1 For other Workstation: 500 GB ultra wide RAID1 for OWS/ 500 GB for Portable EWS
	Communication port	Engineering Cum Operator Workstations: 2 Serial bus. Expansion slot=2 For other Workstation: 4 Serial bus, Expansion slot=2

		Portable EWS: 2 Serial bus.
4.	Monitor (color)	Min 80 cm display size, LED-backlit technology. IPS panel, Graphic Memory = 16 MB. Display to have sufficient number of input ports as required which includes HDMI, USB, display port, LAN (RJ-45) etc as required.
5.	Removable bulk storage drive	2 TB (minimum)
6	Network Connectivity	Engineering Cum Operator Workstations: 4 Nos. Built-in Ethernet Network Port For other Workstation: 2 Nos. Built-in Ethernet Network Port Portable EWS: 1 No. Built-in Ethernet Network Port and 1 No. Wifi
7.	DVD R/W	16x or higher for EWS and OWS
8.	Keyboard	ASCII
9.	Pointing Device	Mouse
10.	Additional general purpose software (for using over network by servers/ workstations/PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc.

11.	Software	MS. Windows latest, MS Office Editor (EXCEL,WORD, POWER POINT), Adobe Acrobat, Anti Virus, Network Security, Etc.

SL No	Feature	Specification
1	Printer	Networked Color Laser Printer
2	Paper Size	A3
3	Printing Speed (minimum) in normal mode for A4 size paper	6 ppm (Color), 24 ppm (B&W)
4	Type	Heavy duty, at least 100 pages/month
5	Resolution (Black) (minimum)	600 dpi
6	First Page Out Time (with full graphic display)	≤ 1 minute for Color, < 45 seconds for B&W
7	Paper Input Capacity (minimum)	500 sheets
8	Additional Features	Automatic Duplex Printing
9	Paper Sheets to be Supplied with Printer	10 reams (A3), 20 reams (A4)

FACTORY ACCEPTANCE TEST (FAT)

FAT procedure shall be submitted by bidder for EFL approval and after approval of FAT procedure, FAT will be witnessed by EFL Engineering or authorized representative of EFL. SCADA shall communicate with all third party devices which are part of BESS System and the same shall be demonstrated during the FAT.

TIME SYNCHRONISATION EQUIPMENT

Time Synchronization equipment shall be provided and shall be located in the Control Room. It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of the SCADA.

It shall be complete in all respects including antenna, all cables, processing equipment, etc.

All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Contractor.

It shall work from DC supplies only and the Contractor to clarify if any built-in battery backup is provided, in which case, same shall be of long life lithium batteries.

It shall be immune to hostile electrical environment. Suitable protections are to be provided against lightning surges and over-voltages in power supply systems and antenna feeders.

The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255.

The GPS shall be synchronized with the SCADA system to be supplied under this contract. Necessary software and Hardware (including laying of communication cable) required for time synchronization with SCADA and all other devises shall be in scope of contractor.

The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.

The system shall have provisions for combination of any of the following output signals:

- NTP (network time protocol) 100Mbits Ethernet port
- IRIG-B00x (TTL, pulse width modulated signal)
- 2 x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts
- Any other output port as may be required for the offered system.
- Alarm status contact indicating healthy status of system

These output ports shall be compatible with the requirement of the equipment to be synchronized i.e. BCUs/ BPUs/Numerical Relays/IEDs etc. as per scope of the specification. The master clock in control room shall also be synchronized with the time synchronization system. The actual port requirements (no./type) in line with the system offered shall be finalized during detailed engineering.

The equipment should have a periodic time correction facility of one-sec periodicity. The equipment shall also have real time display in hour, minute, second (24-hour mode) and have a separate time display, having display size of approx. 144mm height.

11.11 POWER QUALITY METER

Class-A Power Quality Meter, which is fully compliant to IEC61000-4-30, shall be provided and shall be located at the indicated metering points.

i. It shall have a facility for time synchronization on the NTP protocol from the existing GPS clock in the SCADA network.
ii. PQM at the minimum shall measure three-phase voltage & current, power factor, active power, reactive power, harmonics (amplitude and phase), voltage Sag and swell, flicker, disruptions. It should have capability of recording 10 second fault recording during LVRT and HVRT phenomenon as per regulation
iii. It shall be able to communicate with PPC on Modbus TCP/IP protocol
iv. Selected PQM shall be able to measure grid frequency with a minimum of two-digit after the decimal point.
v. All associated software to be supplied for configuration, monitoring & maintenance of PQM to be installed on the EWS cum OWS.

11.12 EMS functionality for the Project Control

The following operation modes can be set from the EMS system:-

i. Automatic mode: This means that a part of the power quantity of the project behaves according to the selected operation mode.
ii. HMI mode or manual mode: in this mode, the operator has the possibility to:
    - Select the operation point
    - Direct control of active and reactive setpoints of the PCS & Solar Inverter.
    - Command of balance of Plant
    - OFF mode: Project is not producing any power. The system is disconnected form the grid.
    - STANDBY-mode: - the PCS & Solar Inverter is connected to the grid, but the IGBT's in the system are in an off-state (i.e. open switching).
iii. Also, the performance of every application mode will be controlled and adaptable by this system. This energy management strategy will be operated by the SCADA in Main Control Room. Any failure in the process or the control system including instrumentation must be detected and logged. This means that the instrumentation, electronic and electrical equipment shall include those failure detections.

iv. A communication with the SCADA system must be possible to receive set points and transmit set points for each application mode. The SCADA should be able to remotely control the BESS. The EMS should allow the SCADA at least the following:

- Change the operation mode of each BESS independently
- Start/Stop each application mode appointed to a BESS.
- Change the application mode of each BESS (multiple modes can be selected together)
- Select the amount of power dedicated to each selected application mode.
- Adapt the parameters needed for the operation of every application mode
- The Communication protocol may be IEC 61850 or MODBUS over a serial or Ethernet connection (Modbus RTU or MODBUS TCP). Other solutions can be proposed but are subjected to the approval of the client.

11.13 EMS functionality for the Plant Control:

The EMS monitors grid and Plant facility variables and should be programmable for selecting the optimum-operating mode of the whole plant through PPC or directly w.r.t. active and reactive power, grid voltage, grid frequency, etc. Additionally, it can receive external set points and automatically adapt the Plant Facility behavior to the new settings.

The EMS shall perform following functionality to Control the Plant facilities: -

- Communication with grid or SCADA
- Communications with BESS and Solar
- Measuring and processing of the electrical magnitudes at EMS (voltage, current, PF)
- Control capability of BESS Inverters, solar Inverters, BESS and other power units

The EMS shall allow following operation modes for the Plant facilities:

- Reactive Control (Q Control, setting point of reactive power Q at EMS)
- Power Factor Control (PF Control, setting point of cos(L) at EMS)
- Voltage Control (V closed loop control, setting point of V at EMS)

- Voltage Droop (Reactive power vs Voltage programmable curve or droop)
- Apparent Power Control (S Lim, setting point of S Lim at EMS)
- Active Power Limitation (P Lim, setting point of P Lim at EMS)
- Power Ramp Rate Control (setting point of maximum %Pn/min)
- Frequency Regulation (Power vs Frequency programmable curve or droop)

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

Measurements

To perform the application modes described above, measurements are needed at the Point of Common Coupling (PCC). The measurements are (but not limited to):

Voltage measurement: This is needed to perform voltage regulation and reactive power compensation.

Output power (Active and Reactive): This will be measured with an accuracy précised by the supplier. The measurement equipment should be class 0.2s.

Control & Power Supply Scheme

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

Software Documentation & Listings

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

11.14 Next Generation Firewall (NGFW) Specification:

11.14.1 General Requirements

Contractor shall provide NGFW having electrical ethernet interfaces/ports and placed between FOTE & SAS gateway/s at the substation. All ethernet based applications shall be terminated in the firewall ports directly (e.g. PMU, AMR, VOIP, SAS/SCADA etc.). Each port of firewall shall work as a separate zone. Firewall shall be hardware based with features of Block/Allow/drop and IPSec VPN (network encryption).

The number of ports/interfaces in each firewall (i.e. Main/Standby) shall be minimum 5 nos. TSP shall provide either single firewall or multiple firewalls to meet this interfaces requirement, each for main as well as standby firewall. Minimum throughput of firewall shall be 200 Mbps.

The Firewall shall be managed/ configured as standalone at present and shall also have compatibility to manage/configure through Centralized Management Console (CMC) remotely in future.

Firewall shall be tested and certified for ISO15408 Common Criteria for least EAL4+.Further, the OEM must certify that it conforms to Secure Product Development Life Cycle requirements as per IEC62443-4-1. The firewall shall generate reports for NERC-CIP Compliance.

11.14.2 Detail Specifications of Next Generation Firewall (NGFW)

NGFW shall have following features including but not limited to:

1. Encryption through IPSec VPN (Virtual Private Network), Deep Packet Inspection (DPI), Denial of service (DoS) & Distributed Denial of Service (DDoS) prevention, Port Block/ Allow, rules/ policies for block/allow, IP (Internet Protocol) & Media Access Control (MAC) spoofing protection, threat detection, Intrusion Prevention System (IPS), Anti-Virus, Anti-Spyware, Man In The Middle (MITM) attack prevention

2. The proposed firewall shall be able to handle (alert, block or allow) unknown/unidentified applications e.g. unknown TCP & UDP packets. It shall have the provision to define application control list based on application group and/or list.

3. Firewall shall have feature and also have capability to update the definition/ Signatures of Anti-Virus online as well as offline. Firewall shall also be compatible to update the definitions/signatures through CMC. There shall be a defined

process for security patching and firmware up-gradation. There shall be a feature to field validate firmware checksum. The same shall also be validated before using the OEM provided file/binary in the process of firmware up-gradation and security patching.

4. Firewall shall have Management Console port to configure remotely.
5. Firewall shall be EMI/EMC compliant in Substation environment as per IEC 61850-3.
6. Firewall shall be rack mounted in existing standard equipment cabinets.
7. Firewall shall have support of SCADA applications (IEC-60870-5-104), ICCP,PMU (IEEE C37.118), Sub-Station Automation System (IEC 61850), Ethernet and other substation environment protocols.
8. Client based Encryption/ VPN must support different Operating System platforms e.g. Windows, Linux & Mac.
9. The solution must have content and comprehensive file detection policies, blocking the files as function of their types, protocols and directions.
10. Firewall shall have logging facility as per standard logs/events format. Firewall shall have features to export the generated/stored logs/events in csv (Comma Separated Value) and also any other standard formats for offline usage, analysis and compliance. Firewall shall have suitable memory architecture and solution to store and be enable to export all logs/events for a period of last 90 days at any given time.
11. Firewall shall have features and be compatible with local as well as central authentication system (RADIUS, LDAP, or TACACS+) for user account and access right management. It shall also have Role Based User management feature.
12. Firewall shall have the capability to configure sufficient number of VLANs.
13. Firewall shall have the capability to support sufficient number of sessions.
14. Firewall shall have provision to configure multiple IP Sec VPNs, at least 100 nos., (one-to-many or many-to-one). Shall support redundant operation with a similar router after creation of all the IP Sec VPN. IPSec VPN shall support encryption protocols as AES128, AES256 and hashing algorithms as MD5 and SHA1. IPSec VPN throughput shall support at least 200 Mbps.

15. Firewall shall be capable of SNMP v3 for monitoring from Network Management system. It shall also have SNMPv3 encrypted authentication and access security.

16. Firewall shall support in Active/Passive or Active-Active mode with High Availability features like load balancing, failover for firewall and IPsec VPN without losing the session connectivity.

17. Firewall should have integrated traffic shaping (bandwidth, allocation, prioritization, etc.) functionality.

18. Shall support simultaneous operation with both IPv4 and IPv6 traffic.

19. Firewall shall be compatible with SNTP/NTP or any other standards for clock synchronization.

20. Firewall shall have the features of port as well as MAC based security.

21. Firewall shall support exporting of logs to a centralized log management system (e.g. syslog) for security event and information management.

22. Firewall time shall be kept synchronised to official Fijian Timekeeping agency.

23. Firewall product shall be provided with all applicable updates at least until 36 months since the applicable date of product shipping to the concerned utility.

12. CENTRALIZED CONTROL SYSTEM (MASTER EMS, REMOTE TERMINAL UNITS (RTUs) & WIRELESS DIGITAL RADIO COMMUNICATION SYSTEM)

12.1 GENERAL AND SCOPE OF WORK

This specification covers the design, engineering, type/factory testing, supply, installation, testing, and commissioning of a Centralized Control System (CCS) comprising a Master Energy Management System (EMS)/SCADA, Remote Terminal Units (RTUs), and an associated Wireless Digital Radio Communication System, for unified real-time monitoring and coordinated optimum dispatch of the following generation sources feeding the grid:

- Solar Photovoltaic (PV) + Battery Energy Storage System (BESS) Plant
- Diesel Generator (DG) Power Plant
- Bagasse (Biomass) Co-generation Power Plant

The Master EMS/SCADA shall be located at the Central Control Centre (CCC), housed within the Solar+BESS Plant control room. The Bagasse Power House and the DG Power House are located approximately 40 (forty) km from the CCC and shall each be equipped with a dedicated Remote Terminal Unit (RTU) that communicates with the CCC over a Wireless Digital Radio link.

The CCS shall, at all times:

- Monitor the real-time load, availability and generation capacity of each of the three sources;
- Monitor grid requirement/interconnection parameters;
- compute and communicate optimum generation reference commands to each plant for coordinated, efficient dispatch;
- Upon detection of a grid disturbance or abnormal condition, automatically determine and communicate the appropriate corrective action to each power plant in accordance with a pre-defined control algorithm, so as to preserve system/grid stability, protect plant and personnel, and maintain continuity of supply to the extent possible.

The Contractor shall include in its scope of supply all Hardware, Software, Panels, Radio Communication Equipment, Antenna/Tower Structures (as applicable), Cabling, GPS Time Synchronization Equipment, Cyber-Security Equipment and associated accessories necessary for the complete, safe and reliable functioning of the CCS, even where an item is not specifically listed in this specification but is necessary for completeness, in line with the philosophy of the Solar+BESS Plant

EMS/SCADA specification (Section referenced as B-6) of which this specification forms a coordinated extension.

12.2 SYSTEM ARCHITECTURE AND CONTROL PHILOSOPHY

12.2.1 Control Hierarchy

The CCS shall be structured as a five-level hierarchical control system:

- **Level 0 — Field Devices:** Inverters, PCS, DG alternator/governor & AVR, boiler-turbine controls at the Bagasse plant, meters, relays, breakers.
- **Level 1 — Local Plant Controllers:** Existing/local Power Plant Controller (PPC) of the Solar+BESS plant (per the B-6 EMS/SCADA specification), DG synchronizing/governor control panel, and Bagasse plant DCS/PLC — each capable of stand-alone safe operation.
- **Level 2 — Site RTU / Data Concentration:** RTUs at the Bagasse Power House and DG Power House aggregating local data and executing dispatch setpoints received from the CCC; local Solar+BESS site data is acquired directly by the Master EMS/SCADA (no separate RTU required at the Solar+BESS site as it hosts the CCC).
- **Level 3 — Central Control Centre (Master EMS/SCADA + MGC):** Central dispatch computation, optimum generation algorithm, grid-event response algorithm, historian, reporting.
- **Level 4 — Grid Interface:** Interconnection with the Grid/Employer's National Control Centre (NCC); CCC shall receive grid demand/curtailment instructions and shall report aggregated plant status upstream.

12.2.2 Central Control Centre (CCC) — at Solar+BESS Plant

The CCC shall comprise the redundant Master EMS/SCADA servers, redundant Master Generation Controller (MGC), redundant Operator Work Stations (OWS), Engineering Work Station (EWS), Historian, GPS Master Clock, NGFW/cyber-security equipment, printer, and the radio base-station equipment for both remote links, all housed in the Solar+BESS Plant control room.

12.2.3 Remote Sites — Bagasse Power House and DG Power House

Each remote site (~40 km from CCC) shall be equipped with a dedicated RTU panel, local I/O wired to the respective plant's instrumentation and controllers, a GPS/NTP

slave time-reference, radio remote-station equipment, and a local firewall/secure gateway.

12.2.4 Communication Backbone

Communication between the CCC and each remote RTU shall be over a dedicated Wireless Digital Radio link as detailed in Section 7. Communication within the Solar+BESS site (CCC to local plant PPC/inverters) shall continue as per the existing specification.

12.3 FUNCTIONAL REQUIREMENTS

12.3.1 Real-Time Load and Capacity Monitoring

The CCS shall continuously acquire, display, log and make available for the dispatch algorithm the following minimum parameters from each of the three sources:

Parameter	Solar+BESS	DG	Bagasse
Real-time active power (MW) & reactive power (MVAr)	Yes	Yes	Yes
Installed / rated capacity	Yes	Yes	Yes
Available (de-rated) capacity, real time	Yes	Yes	Yes
Ramp-up / ramp-down capability (MW/min)	Yes	Yes	Yes
Minimum stable / must-run loading	BESS only	Yes	Yes
Resource availability (irradiance / SOC%)	Yes	—	—
Fuel level / running hours	—	Yes	—
Bagasse fuel stock & boiler steam availability	—	—	Yes
Plant / unit availability & health status	Yes	Yes	Yes
Breaker & interconnection status	Yes	Yes	Yes

12.3.2 Grid Requirement Monitoring

At the grid Point of Common Coupling(s), the CCS shall continuously monitor:

- Grid frequency and Rate of Change of Frequency (RoCoF)
- Grid voltage (three-phase) and power factor
- Grid demand / curtailment or dispatch instruction, where an interface with the Employer's NCC/AGC system is provided
- Interconnection / tie breaker status and loss-of-grid signal
- Under-frequency, over-frequency and voltage-excursion conditions against configurable threshold bands

12.3.3 Centralized Optimum Generation Dispatch Algorithm

The MGC (Master Generation Controller) at the CCC shall run a coordinated economic/optimum dispatch algorithm at a configurable execution cycle (typically 1–5 seconds, to be finalized during detailed engineering) that computes an active power (and, where applicable, reactive power) reference setpoint for each of the three plants, subject to the following minimum considerations:

- **Renewable-first utilization:** Solar generation shall be treated as a must-take resource; BESS charge/discharge scheduling shall be optimized for both grid support and State-of-Charge (SOC) management within configurable SOC bands.
- **Plant technical constraints:** Ramp-rate limits, minimum stable generation, ramp-hold during transients, and unit availability of DG and Bagasse plant shall be respected in every dispatch cycle.
- **Fuel/resource optimization:** DG fuel consumption and Bagasse fuel-stock/steam availability shall be weighted in the merit order used to meet any residual demand not covered by Solar+BESS.
- **Grid demand tracking:** The aggregate reference output of all three plants shall track the grid demand/instruction received from the Employer's NCC (Level 4) within a configurable tolerance band.
- **Setpoint dispatch:** Computed MW (and MVAr, where applicable) references shall be transmitted from the CCC to the local PPC (Solar+BESS) and to each remote RTU (DG, Bagasse) for execution by the respective local controller.
- **Operator override:** The dispatch algorithm's weighting factors, priority order, SOC bands and constraint limits shall be configurable and overridable from the EWS/OWS under password-protected access; a manual/HMI mode (Clause 4.5) shall allow the operator to directly set plant references.

12.3.4 Grid Contingency / Corrective-Action Algorithm

On detection of a grid abnormality, the CCS shall automatically execute a pre-defined corrective-action sequence, without waiting for operator intervention, as follows:

- **Detection:** Grid loss, under/over-frequency, under/over-voltage or RoCoF excursion beyond configurable thresholds shall be detected at the CCC (and independently at each RTU as a local back-up check) within a maximum detection time to be finalized during detailed engineering.
- **Response matrix:** A pre-configured cause-and-effect / response matrix (e.g. BESS transition to grid-forming/VSG mode, DG frequency-support droop response, Bagasse plant safe run-back, load-shedding priority order, controlled islanding and, where applicable, black-start sequencing) shall define the corrective command issued to each plant for each category of disturbance.
- **Command dispatch:** Corrective commands shall be transmitted from the CCC to all three plants simultaneously (broadcast) with the highest communication priority on the radio links, ahead of routine polling traffic.
- **Fail-safe on communication loss:** If a remote RTU loses communication with the CCC, the local PPC/RTU logic at that plant shall automatically revert to a pre-configured safe/last-good-setpoint or independent local-control mode, as finalized during detailed engineering, so that loss of the radio link alone does not compromise plant or grid safety.
- **Logging:** The complete sequence of detection, computed response, transmitted commands, and plant acknowledgements shall be time-stamped (Section 8) and logged in the Historian for post-event analysis.

12.3.5 Operating Modes

The CCS shall support the following selectable operating modes, consistent with the EMS operating-mode philosophy of the Solar+BESS Plant EMS:

- **Automatic (Central Dispatch) Mode:** The MGC computes and transmits reference setpoints to all plants per Clause 3.3/3.4.
- **Manual / HMI Mode:** Operator directly sets the reference for each plant from the OWS/HMI.
- **Local / Islanded Mode:** Each plant's local controller (PPC/RTU) operates independently of the CCC using its last valid or locally configured setpoint, automatically invoked on communication loss (Clause 3.4) or manually selectable for maintenance.
- **Test / Simulation Mode:** Allows the dispatch and contingency algorithms to be exercised against simulated inputs without issuing live commands to plant, for commissioning and operator training.

12.4 MASTER EMS / SCADA AT THE CENTRAL CONTROL CENTRE

The Master EMS/SCADA at the CCC shall extend the functional and hardware philosophy of the existing Solar+BESS Plant EMS/SCADA to additionally acquire, display, log and control the DG and Bagasse plants over the RTU/radio links, and to host the Master Generation Controller (MGC) described below. Except where varied in this Section, all general EMS/SCADA, HMI, historian, reporting, security, and software requirements of the specification shall apply equally to the CCC system.

12.4.1 Master Generation Controller (MGC)

- The MGC shall be provided with two processors (main and hot-standby), each with its own memory, mirroring the redundancy philosophy specified for the Power Plant Controller (PPC) in the specification.
- Transfer from the main to the standby MGC processor shall be automatic, bumpless, and shall not cause plant disturbance or loss of dispatch continuity; either processor shall be assignable as master.
- The MGC shall directly interface with the Solar+BESS local PPC over the plant LAN, and with the Bagasse/DG RTUs over the wireless radio links, to issue reference setpoints and receive plant status independently of the general SCADA polling cycle.
- The MGC shall host the configurable dispatch algorithm (Clause 3.3) and grid-contingency response matrix (Clause 3.4), with password-protected engineering access from the EWS.

12.4.2 SCADA, HMI, Historian and Reporting

- Redundant SCADA servers and redundant OWS, an EWS (desktop) and a portable (laptop) EWS shall be provided at the CCC, per the hardware requirements.
- Single Line / Mimic diagrams shall display the Solar+BESS, DG and Bagasse plants and the grid interconnection on a unified plant overview screen, in addition to individual plant mimics, using standard colour coding.
- The Historian shall log all data listed in Section 8, plus all dispatch setpoints, algorithm mode changes and contingency-event sequences, at the intervals specified in Section 10.
- User-configurable periodic (daily/monthly/annual) reports shall be generated in MS Excel/PDF format, covering generation-mix, dispatch performance, and grid-event summaries.

- Web-based remote monitoring, authenticated by user ID/password, shall be provided consistent with Clause requirements of the specification.

12.5 REMOTE TERMINAL UNIT (RTU) SPECIFICATION

A dedicated RTU shall be provided at the Bagasse Powerhouse and at the DG Powerhouse (or a single RTU panel with adequate I/O/segregation if the two plants are confirmed co-located per the Note in Section 1). Each RTU shall perform local data acquisition; local execution of dispatch/contingency commands received from the CCC and shall provide store-and-forward buffering during communication interruptions.

12.5.1 RTU Processor and Redundancy

- Each RTU shall be provided with dual (main + hot-standby) processors and power supplies; failure of the working processor shall raise an alarm and cause automatic, bumpless transfer to standby without disturbance to the connected plant.
- Each RTU shall have not less than 20% spare processing capacity and not less than 20% spare I/O capacity of each type, over and above the implemented requirement, consistent with the specification.

12.5.2 Input/Output and Isolation

- I/O modules (analog 4–20 mA, digital contact input/output, pulse/RTD as required) shall be provided for all field signals from the DG and Bagasse plant instrumentation and controllers, per the data-point list of Section 8.
- Electrical isolation of 1.5 kV with optical couplers shall be provided between field I/O and the RTU processor, to protect against induced voltage spikes.
- Not less than 10% spare I/O channels, fully wired to terminal blocks, shall be provided in each RTU cabinet.

12.5.3 Local Control Logic and Store-and-Forward

- Each RTU shall execute a local safe-control logic (Clause 3.4/3.5) enabling the connected plant to continue safe operation on loss of the radio link, reverting to a pre-configured setpoint/mode.
- Each RTU shall buffer time-stamped data locally for a minimum duration to be finalized during detailed engineering (recommended not less than 24 hours) and shall automatically upload the buffered data to the CCC Historian upon restoration of the radio link, without loss or duplication of records.

12.5.4 RTU Panel, Enclosure and Environment

- RTU cabinets shall be of minimum IP-42 protection class for installation within an air-conditioned/sheltered control room at each plant, consistent with the SCADA cabinet philosophy; any RTU/radio equipment located in a non-air-conditioned outdoor enclosure shall be rated minimum IP-65.
- All power-supply modules, Ethernet switches and network accessories located in non-air-conditioned areas shall be suitable for continuous operation at ambient temperatures up to 50°C.
- Each RTU shall be provided with dual power-supply feeders (DC/UPS) with alarm on single-feeder failure, per the philosophy of Clause on SCADA panel power supply.

12.6 WIRELESS DIGITAL RADIO COMMUNICATION SYSTEM

The CCC (at the Solar+BESS Plant) and the RTUs at the Bagasse Powerhouse and DG Powerhouse, approximately 40 km distant, shall be interconnected by a dedicated Wireless Digital Radio communication system, engineered as follows.

12.6.1 General and Link Configuration

- The Contractor shall provide a point-to-point (or point-to-multipoint, where the remote plants are confirmed co-located) licensed digital radio link between the CCC and the remote RTU site(s), covering a nominal path length of 40 km.
- The link shall operate in a frequency band appropriate to the path length and terrain (VHF/UHF or licensed microwave, to be selected during detailed engineering based on the path survey), subject to frequency allocation/spectrum licensing by the Employer's national telecommunications regulator (e.g. the Telecommunications Authority of Fiji — TAF, or equivalent, as applicable to the project country).
- The Contractor shall be responsible for obtaining, or assisting the Employer in obtaining, all requisite radio-frequency license(s), equipment type-approval, and path/spectrum clearance prior to installation.

12.6.2 Path Engineering and Line-of-Sight

- The Contractor shall carry out a detailed path/link survey, including terrain profile, Fresnel-zone clearance analysis and a link budget calculation, and shall submit the Path Survey Report for Employer approval prior to procurement of radio and tower hardware.

- Tower/mast height at each end shall be sized to achieve adequate first Fresnel-zone clearance over the full 40 km path under worst-case atmospheric refraction (k-factor) conditions.
- A minimum fade margin of 20 dB (to be confirmed during detailed engineering based on rain-zone/climatic data) shall be maintained to ensure link availability of not less than 99.9% on an annual basis.
- Where a single-hop 40 km path cannot achieve reliable line-of-sight due to terrain, the Contractor shall propose an intermediate repeater station, subject to Employer approval, at no functional or performance compromise to the specification.

12.6.3 Radio Equipment Technical Specification

Parameter	Requirement
Link type	Licensed point-to-point (or point-to-multipoint) digital radio, full-duplex (FDD)
Nominal path length	~40 km (site-specific, per path survey)
Modulation	Adaptive digital modulation (e.g. QPSK to higher-order QAM), vendor standard for licensed PtP radios
Minimum data throughput	Sized for full SCADA I/O + dispatch/contingency traffic + 25% spare capacity; minimum 2 Mbps net or as computed during detailed engineering
Protocol support	Ethernet (TCP/IP) transparent bridging; native support for IEC 60870-5-101/104 and/or DNP3 and Modbus TCP/RTU tunnelling
Latency (one-way, radio link)	Not to exceed 20 ms, to support the dispatch/contingency response-time requirements of Section 4
Transmit power / receiver sensitivity	As required to close the link budget of Clause 6.2 with the specified fade margin; to be furnished by Contractor with the Path Survey Report
Antenna	High-gain directional (parabolic/panel) antenna suitable for 40 km licensed link, with weatherproof radome
Encryption	AES-256 payload encryption with mutual authentication between radio end-points

Parameter	Requirement
Enclosure / environment	Outdoor unit (ODU): IP-65 minimum, –10°C to 55°C; Indoor unit (IDU): rack/panel mounted in RTU/CCC cabinet
Surge / lightning protection	Coaxial/Ethernet surge arrestors at both ends, tower earthing and bonding per applicable standard
Reliability	MTBF and manufacturer's field-proven reliability data to be furnished; hot-standby radio modem recommended (Clause 6.4)
Management	SNMPv3-capable network management with RSSI, BER and link-availability reporting to the Master SCADA (Clause 6.5)

12.6.4 Redundancy

- A hot-standby radio modem with automatic switch-over, and/or frequency diversity on a second licensed channel, shall be provided at both ends of each link, so that a single radio equipment failure does not interrupt communication.
- Where the criticality of grid-contingency commands (Clause 3.4) warrants it, the Employer may additionally evaluate a narrowband backup channel (e.g. licensed VHF data radio) dedicated solely to broadcast of contingency commands, independent of the primary broadband link — to be evaluated and finalized during detailed engineering.

12.6.5 Diagnostics and Link Monitoring

- RSSI, Bit-Error-Rate (BER) and link-availability shall be continuously monitored and trended at the CCC SCADA, with alarm generation on link degradation (below a configurable RSSI/BER threshold) or link loss.
- A dedicated radio-link summary mimic shall be provided on the OWS, showing real-time status of both the primary and standby/diverse radio paths.

12.6.6 Cyber-Security of the Radio Link

- Traffic over the radio link shall be encrypted (AES-256, Clause 6.3) and shall pass through the Next-Generation Firewall (NGFW) at the CCC and a corresponding secure gateway/firewall at each remote RTU site, per Section 11.

- The radio network management interface shall be accessible only from the EWS over an authenticated, role-based-access channel.

12.7 TIME SYNCHRONIZATION

- A GPS Master Clock shall be provided at the CCC, as per the time-synchronization requirements of the EMS/SCADA specification, to synchronize all CCC devices.
- Each remote RTU site shall be provided with its own independent GPS time-reference receiver (rather than relying solely on time distributed over the radio link), so that event time-stamping at each RTU remains accurate and independent of radio-link latency or outage.
- All devices with a real-time clock and time-synchronization capability shall be synchronized to a common UTC reference, with NTP/IRIG-B output ports as required, consistent with the specification's time-synchronization clause.

12.8 DATA POINTS FOR ACQUISITION AND CONTROL (MINIMUM LIST)

In addition to the plant-specific data points already specified in the EMS/SCADA specification for the Solar+BESS plant, the following minimum data-point categories shall be acquired from the DG and Bagasse plants via the respective RTUs, and made available to the MGC for dispatch and contingency computation:

Data Point	Solar+BESS	DG	Bagasse
Active power (MW) / Reactive power (MVAr)	Analog	Analog	Analog
Bus voltage / current / frequency / PF	Analog	Analog	Analog
Available capacity & ramp-rate capability	Calc.	Calc.	Calc.
Fuel level / running hours (DG); Fuel stock / steam pressure (Bagasse)	—	Analog	Analog
Breaker / circuit-switcher status	Digital	Digital	Digital
Unit trip / protection-operated status	Digital	Digital	Digital

Data Point	Solar+BESS	DG	Bagasse
Local/Remote & Auto/Manual mode status	Digital	Digital	Digital
Dispatch reference setpoint (MW/MVAr)	Control	Control	Control
Contingency command (per Clause 4.4 response matrix)	Control	Control	Control
Communication / radio-link health status	Digital	Digital	Digital
Alarm & event summary (per Section 10)	Digital	Digital	Digital

12.9 ALARMS AND EVENTS

As a minimum, the following shall be configured as unsolicited/priority alarms, reported the instant they are detected, in addition to the plant-level alarms already specified for the Solar+BESS plant in the specification:

- Loss of grid / grid frequency or voltage excursion beyond threshold
- Radio link failure or degraded-link warning (RSSI/BER threshold exceeded), for each of the CCC–RTU links
- RTU processor failure / changeover to standby
- Plant deviation from dispatched reference beyond a configurable tolerance
- DG fuel level low; Bagasse fuel-stock/steam availability low
- BESS SOC high/low limit
- Plant trip / protection operation at any of the three plants
- Contingency algorithm activation and completion (with full command sequence logged)

12.10 HISTORICAL STORAGE AND RETRIEVAL SYSTEM (HSRS)

- The Historian shall collect and store data from the CCC and both remote RTUs online, with automatic transfer to non-erasable long-term storage media periodically (recommended every 30 days), consistent with the specification's HSRS clause.
- PCS/DG/Bagasse operating parameters and MFM/energy-meter data shall be stored at 1-minute resolution; BESS/BMS SOC and dispatch reference/actual

values shall be stored at 1-second resolution, mirroring the storage table of the specification.

- All dispatch setpoints, algorithm-mode changes and contingency-event sequences (Clause 3.4) shall additionally be stored with full time-stamping for the operational life of the plant.
- Two (2) numbers of portable external hard-disk drives of 2 TB each shall be provided for long-term offline data retention, per the specification requirement.

12.11 CYBER-SECURITY (NEXT GENERATION FIREWALL)

The Next-Generation Firewall (NGFW) requirements of the EMS/SCADA specification shall apply in full at the CCC, and shall additionally be extended as follows to protect the wide-area radio links to the remote RTU sites:

- A hardware NGFW (or equivalent secure gateway) shall be provided at the CCC end and at each remote RTU end of the radio link, in Active/Passive or Active-Active high-availability configuration, with the same feature set (IPSec VPN, DPI, DoS/DDoS prevention, IPS, anti-virus/anti-spyware, MITM prevention) specified in the specification.
- All CCC–RTU traffic shall be carried within an encrypted IPSec VPN tunnel (AES-128/AES-256) in addition to the radio-link's native encryption (Clause 6.6), providing defence-in-depth.
- Firewalls shall be tested/certified to ISO 15408 Common Criteria EAL4+ (or higher) and the OEM shall certify conformance to a Secure Product Development Life Cycle per IEC 62443-4-1, consistent with the specification.
- Role-based access control with local and centralized (RADIUS/LDAP/TACACS+) authentication shall be implemented uniformly across the CCC and both remote sites.
- Logs/events from all firewalls shall be exported to a centralized log-management (syslog) system at the CCC for security event and information management, with a minimum 90-day rolling online retention.

12.12 HARDWARE REQUIREMENTS SUMMARY

The following summarizes the principal hardware groups to be supplied. Detailed workstation/server specifications (processor, memory, storage, display, ports) shall follow the HMIPIS hardware table of the EMS/SCADA specification for all CCC workstations/servers; RTU and radio hardware shall meet the requirements below.

Item	Location	Reference
Master EMS/SCADA servers (redundant)	CCC	As per relevant section
Master Generation Controller (MGC), redundant processors	CCC	As per relevant section
Operator Work Stations (redundant), EWS (desktop + portable)	CCC	As per relevant section
Historian server	CCC	As per relevant section
GPS Master Clock	CCC	As per relevant section
NGFW / secure gateway	CCC & each remote site	As per relevant section
Networked colour laser printer	CCC	As per relevant section
RTU panel (dual redundant processor, I/O modules)	Bagasse PH & DG PH	As per relevant section
GPS time-reference receiver	Each remote site	As per relevant section
Radio IDU/ODU, antenna, tower/mast, surge protection	CCC & each remote site	As per relevant section
UPS / DC power supply system (dual feeder)	CCC & each remote site	As per relevant section
Portable external HDD (2 TB) — 2 nos.	CCC	As per relevant section

12.13 SOFTWARE REQUIREMENTS

- Industry-standard operating system (latest Windows or equivalent industrial OS), MS Office suite, Adobe Acrobat, anti-virus and network-security software at all workstations/servers, per the specification.
- EMS/SCADA application software: input scanning/acquisition/conditioning, control, communication, operator-interface displays/trends/reports, and Historian storage/retrieval, per the specification.
- Central Dispatch Optimization Engine implementing the algorithm of Clause 3.3, with an engineering-level configuration utility (weighting factors, priority order,

SOC bands, ramp/constraint limits) accessible from the EWS under password protection.

- Grid-Contingency Response Engine implementing the response matrix of Clause 3.4, independently configurable and testable in Test/Simulation mode (Clause 3.5).
- Protocol driver software for Modbus (TCP/IP, RTU, ASCII), IEC 60870-5-101/104 and/or DNP3, and IEC 61850 (for the Solar+BESS plant LAN).
- Radio network-management software (SNMPv3) for both links, integrated with the SCADA alarm system per Clause 6.5.
- All software licenses shall be project/site licenses, not hardware/machine-specific, valid for the continuous service life of the plant, and delivered with license keys on SSD media to the Employer, consistent with the B-6 specification's software-licensing clause.

12.14 SYSTEM SPARE CAPACITY

- 10% spare, fully wired I/O channels at each RTU and at the CCC I/O cabinets, consistent with the specification.
- 20% spare functional/processing capacity at the MGC and at each RTU processor for additional function blocks and future I/O, consistent with the specification.
- 25% spare data-communication/throughput capacity on both the plant LAN and the wireless radio links, over and above the calculated real-time requirement (Clause 6.3).
- Wired-in usable cabinet space for 10% additional modules at the CCC and each RTU, per the specification's spare-capacity clause.

12.15 FACTORY AND SITE ACCEPTANCE TESTING

12.15.1 Factory Acceptance Test (FAT)

- A FAT procedure shall be submitted for Employer approval and witnessed by the Employer/authorized representative, covering the CCC (Master EMS/SCADA + MGC) and both RTU panels, per the specification's FAT clause.
- The dispatch algorithm (Clause 3.3) and grid-contingency response matrix (Clause 3.4) shall be demonstrated in Test/Simulation mode using simulated plant and grid inputs.
- Communication between the MGC and simulated RTUs (Modbus/IEC 60870-5-104/DNP3) shall be demonstrated during FAT.

12.15.2 Radio Link Testing

- The Path Survey Report (Clause 7.2) shall be submitted and approved prior to site installation of tower/radio hardware.
- Following installation, the Contractor shall demonstrate, and log, end-to-end link availability, RSSI/BER, and round-trip latency over the full 40 km path for a continuous period (recommended 72 hours) prior to Site Acceptance.

12.15.3 Site Acceptance Test (SAT) and Integrated System Test

- Live end-to-end testing of dispatch-setpoint transmission and plant response for each of the three plants, individually and simultaneously.
- Simulated grid-contingency trial(s), with all three plants connected, to validate the response-matrix timing and sequence of Clause 3.4, in a manner that does not endanger plant, personnel or the live grid (e.g. using test/simulation inputs with outputs blocked from live plant, or during a scheduled maintenance window, as agreed with the Employer).
- Verification of automatic fail-safe/local-mode transition at each RTU upon deliberate, controlled interruption of the radio link.

12.16 DOCUMENTATION, TRAINING AND SPARES

- Complete technical manuals, reference manuals, cause-and-effect/logic diagrams, and as-built drawings, in English, for the CCC, both RTUs and the radio system shall be furnished, per the specification's software-documentation clause.
- The dispatch-algorithm and contingency-response-matrix configuration/source documentation shall be furnished in sufficient detail for the Employer's engineers to review, and where applicable, modify, the configurable parameters.
- All software, with license keys, for the CCC, RTUs and radio network-management system shall be handed over to the Employer on SSD media.
- O&M training shall be provided for Employer's engineers at the CCC and at both remote RTU sites, covering normal operation, all operating modes (Clause 3.5), alarm response, and radio-link diagnostics; duration to be finalized during detailed engineering.
- Recommended mandatory/insurance spares for the RTUs and radio equipment (e.g. spare radio modem, spare RTU processor card, spare I/O modules) shall be quoted separately by the Contractor.

12.17 SCOPE MATRIX

Item	Contractor Scope	Employer / EFL Scope
Master EMS/SCADA & MGC hardware and software (CCC)	Contractor	—
RTU panels, I/O and local control logic (Bagasse PH & DG PH)	Contractor	—
Radio equipment (IDU/ODU, antenna) — both ends, both links	Contractor	—
Tower / mast structure & foundation	Contractor (to be finalized)	To be confirmed at detailed engineering
RF frequency license / spectrum allocation application	Contractor to prepare; Employer to co-sign/support as license-holder of record	Employer, as applicable under local regulation
Power supply (AC/DC/UPS) at each remote RTU site	Contractor to specify; tie-in to existing plant supply	Employer to provide tie-in point
Existing Solar+BESS plant LAN & PPC interface (per B-6 spec)	Contractor	—
Civil works for RTU cabinet room / radio tower foundation	To be finalized	To be finalized
NGFW / cyber-security equipment, all sites	Contractor	—
GPS time-reference equipment, all sites	Contractor	—
FAT / SAT / Path Survey witnessing	Contractor to conduct	Employer to witness
O&M training & documentation handover	Contractor	—

13. EARTHING SYSTEM

13.1 GENERAL REQUIRMENTS

This specification is intended to outline the requirement of earthing (grounding) for Solar array (DC) side and AC Power block side of Solar PV Project. It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of earthling system meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of earthling system for safe and satisfactory operation of the plant shall be included under scope of the bidder.

Earthing requirement for outdoor metering yard/Switchyard has been mentioned elsewhere in the specification and hence shall be excluded from scope of this chapter unless earthing requirement of metering yard/Switchyard is specifically mentioned in this chapter.

Electrical Resistivity Test (ERT) of the soil is included in the scope of bidder.

13.2 Earthing Design Requirement

The object of protective earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose of this is to ensure that, in general, all parts of apparatus other than live parts, shall be at earth potential, as well as to ensure that operators and attendants shall be at earth potential at all times. Also, by providing such an earth surface of uniform potential under and surrounding the station, there can exist no difference of potential in a short distance big enough to shock or injure an attendant when short-circuits or other abnormal occurrences take place.

Care must be taken for equipment with functional earthing that its service is not disrupted due to undesired disturbances in protective earthing system.

13.3 Codes And Standard

The equipment/product furnished for earthing system shall meet the requirements of all the applicable relevant National/International codes and standards or their latest

amendment Codes and Standards. Product certification has to be CE/UL/BIS/TUV or equivalent. The relevant codes and standard for earthing system are tabulated below.

Standard / Code	Description
IEC 60364-5-54	Code of practice for Earthing.
IEEE: 80	IEEE guide for safety in AC substation grounding.
IEEE: 837	Standard for qualifying permanent connections used in substation grounding.
IEC 62305	Code of Practice for the protection of building and allied structures against lightning.
IEEE 951	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
ISO 1461/ASTM A123/A123M	Recommended practice for hot dip galvanizing of iron & steel.
ISO 1461/ASTM A123/A123M	Method for testing uniformity of coating on zinc coated articles.
ASTM A1008	Cold rolled low carbon steel sheets and strips.
ISO 1460	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
EN 10025-2	HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL — SPECIFICATION.
ISO 8179-1/ISO 1461	Hot-dip Zinc coating for MS Tubes.
EN 1916	Precast Concrete Pipes (With and Without Reinforcement).
UL-467	Grounding and Bonding Equipment.
IEC 62561-7	Requirements for earthing enhancing compounds.

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (codes and standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the above standards/ codes as applicable.

The earthing system includes earth electrode, installation of earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of

earth electrode with equipotential earth bus and connection of equipment to equipotential earth bus.

13.4 EARTH ELECTRODE

The earth electrode is in direct contact with the ground provides means for conducting earth current with ground. Earth Electrode material should have good electrical conductivity and mechanical strength and should not corrode in wide variety of soil conditions. For an effective earthing system, following type of vertical earth electrodes can be used.

- MS Rods

Hot rolled, Medium or High Tensile Steel Rod as per EN 10025-2 of length not less than 3000 mm.

- Copper Bonded Rods

High tensile-low carbon steel rod having diameter not less than 14/17 mm of Length 3000 mm to be selected based on earth fault current. The Rod shall comply with requirements of BS 4360 Grade 43A or EN10025:2-004 S275JR, molecularly bonded by 99.99% pure high conductivity copper on outer surface with copper coating thickness 250 micron or more in conformity to UL-467. Its surface shall be clean, free from mechanical defect and any visible oxide layer or foreign material.

13.5 Earthing Enhancement Compound

A low resistance earth electrode system is important to provide a low impedance path for the better dissipation of lightning/fault currents, and to protect personnel and equipment by minimizing and equalizing voltage potential differences. Earthing (ground) enhancement materials shall be used to improve the ground electrode resistance. Earth enhancement material shall be a superior conductive material which improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It shall be tested and should conform to the requirements of IEC 62561-7.It shall have the following characteristics:

a) High conductivity, improves earth's absorbing power and humidity retention capability, non-corrosive in nature having low water solubility but highly hygroscopic.
b) Carbon based with min 95% of fixed carbon content premixed with corrosion resistant cement to have set properties. Cement shall not mix separately & shall not have Bentonite.

c) Resistivity of less than 0.2 ohms -meter.
d) It shall not depend on the continuous presence of water to maintain its conductivity and shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time.
e) It shall not dissolve, decompose or leach out with time and shall be environmental friendly, suitable for soils of different resistivity and any kind of earth electrode.

The Earth enhancement material shall be supplied in sealed, moisture proof bags, marked with Manufacturer's name or trade name, quantity etc. The minimum quantity of earth enhancement compound to be used with each earth-pit shall be 25 Kg.

13.6 Earthing conductor

Earthing conductor is the conductor for buried below the ground at the depth of 600 mm connecting earth pits to make interconnection of earth pit. To interconnect earth pits, following type of conductor can be used. Application of specific conductor and its size has been mentioned in relevant clause:

a) Galvanised Steel Flat (GS) Flat
GS/GI Flat (Strip) conductor shall comply to IEC 60076 with Galvanization of 85 Micron as per IS. Material shall be clean and free form mechanical defects.
b) Copper Clad Steel (CCS) Earthing Conductor
The Copper Bonded Steel Grounding Conductor shall be made of steel with the coating of 99.99% pure copper complying to ASTM B 869-96 and ASTM B 452-93 standards. Each strand of CCS shall have continuous, uniform coating and the conductor surface shall be smooth and free from mechanical defects.
c) MS Rod
Hot rolled, Medium or High Tensile Steel Rod as per IEC 10025-2 of length not less than 3000 mm and diameter of 40 mm.

13.7 Earthing Technical and Installation Requirement

Careful consideration should be given to installing an earthing system that meet or exceed statutory requirements. Contractor shall select certified product and ensure good workmanship for installation for satisfactory performance to fulfill the designed parameters all the times. Following care shall be taken while installation of earthing.

1. Metallic frame/ structure of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity, Crane rails, tracks, metal pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs, and rails etc. of the building housing

electrical equipment shall be connected to the nearby earthing grid conductor by one earthing ensured by bonding the different sections of hand rails and metallic stairs. Metallic sheaths/screens, and armour of multi-core cables shall be earthed at both ends. Metallic Sheaths and armour of single core cables shall be earthed as per requirement mentioned elsewhere in the specification. Every alternate post of the switchyard fence shall be connected to earthing grid by one GS flat and gates by flexible lead to the earthed post. Portable tools, appliances and welding equipment shall be earthed by flexible insulated cable. Metallic column for Inverter/Switchgear shelter/E-house shall be earthed with two distinct connections at minimum two column. All the wall cladding section shall be earthed at minimum two location with flexible copper cable of not less than 50 sq. mm.

2. Each continuous laid lengths of cable tray shall be earthed at minimum two places by G.S. flats to earthing system, the distance between earthing points shall not exceed 30 meter. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground.
3. Neutral connections and metallic conduits/pipes shall not be used for the equipment earthing. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level.
4. The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.
5. Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti-corrosive paint/compound.
6. Suitable earth risers as approved shall be provided above finished floor/ground level, if the equipment is not available at the time of laying of main earth conductor.
7. Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding. Resistance of the joint shall not be more than the resistance of the equivalent length of conductors.
8. Earthing conductors buried in ground shall be laid minimum 600 mm below grade level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm.
9. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.
10. A minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench/foundation/underground pipes at crossings. Earthing conductors crossings the road can be installed in pipes. Wherever earthing

conductor crosses or runs at less than 300 mm distance along metallic structures such as gas, water, steam pipe lines, steel reinforcement in concrete, it shall be bonded to the same. Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding / cleating at interval of 1000mm and 750mm respectively.

11. Earth pit shall be constructed as per IEC 60364-5-54. Electrodes shall be embedded preferably below permanent moisture level. Minimum spacing between electrodes shall be 600mm.
12. Earth pits shall be treated with earth enhancement compound if resistivity is more than 20 ohm meter.
13. On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded. All equipment required for testing shall be furnished by contractor.
14. Contractor shall obtain all necessary statutory approvals for the earthing system before charging of the plant and electrical equipment.

13.8 TECHNICAL DETAILS FOR AC EARTHING SYSTEM

This section outlines the requirements of protective and functional earthing system to discharge AC fault current to earth and provide equipotential bonding for Transformer, HT and LT Switchgear Panel and other similar electrical equipment, Transformer neutral and shield.

The Contractor shall furnish the detailed design and calculations as per IEEE 80/IEC 60364-5-54 for Employer's approval for equipment earthing.

S. No.	Parameter	Specification
1	Conductors above ground level and in built up trenches	Galvanized steel
2	Conductors buried in earth	Mild steel rod of 40 mm dia (Any alternate proposal by bidder shall be reviewed and decided during detailed engineering based on requirement)
3	Earth electrodes	Mild steel rod of diameter 40 mm or Copper bonded steel rod of dia not less than 17 mm
4	Life Expectancy	25 years
5	Fault Level	Mentioned Elsewhere
6	Min. Steel corrosion	As per IEC 60364-5-54
7	Soil Resistivity	Actual as per site condition

The sizes of earthing conductors for various electrical equipment shall be as below:

S. No.	Equipment	Earth Conductor buried in Earth	Earth Conductor above ground level and in built up trenches
1	33kV/11kV/6.6kV/3.3 kV switchgear equipment and 415V switchgear	--	65 x 8 mm GS flat
2	415 V MCC/Distribution boards/Transformers	--	50 x 6 mm GS flat
3	LT Motors above 125 kW	--	50 x 6 mm GS flat
4	LT Motors 25 kW to 125 kW	--	25 x 6 mm GS flat
5	LT Motors 1 kW to 25 kW	--	25 x 3 mm GS flat
6	Fractional House Power Motor	--	8 SWG GS wire
7	Control Panel & Control Desk	--	25 x 25 x 3 mm GS flat / 25 sq mm Cu cable
8	Push Button Station / Junction Box	--	8 SWG GI wire
9	Columns, Structures, Cable Trays and Bus Duct Enclosures	--	50 x 6 mm GS flat
10	Crane, rails, rail tracks & Other non-current carrying metal parts	**--**	25 x 6mm GS flat

Contractor shall ensure there at least two earth pits each dedicated for earthing of each Transformer, HT/LT Switchgear panel, transformer neutral, Battery Charger/UPS/Control Panel etc. shall be provided. Earth electrode shall be located near to the equipment and all earth electrodes shall be interconnected with parallel conductor buried in earth surrounding the equipment.

Earthing system of different locations such as Inverter room/Pooling Switchgear/Sub pooling switchgear/Inverter shelter etc. shall be interconnected in single network of earthing with buried conductor of the size 65X8 MS Flat laid at 600 mm depth (if specifically required to achieve the earth resistance value within the acceptable limit

based on the soil property of site). Contractor shall submit the calculation based on the system of earth conductor and electrode connected in single network. Location and manner of interconnection shall be approved during detail engineering.

For functional earthing of electronic component such as SCADA, contractor shall provide 1 no. (Min) isolated earth electrode near to the equipment connected with 2 run of copper cable of size not less than 25 sqmm. Contractor shall comply to the recommendation of OEM (Original Equipment Manufacturer) for electronic earthing and electrode can be connected with other earth electrode as per recommendation of OEM.

Each inverter duty transformer having shield between HV and LV winding shall be provided with 2 nos. Isolated earth electrode connected with each other for functional earthing of transformer shield. Each electrode shall be connected with transformer shield with separate 25X6 Cu flat.

13.9 TECHNICAL DETAIL SOLAR ARRAY (DC) EARTHING

This section outlines the earthing requirement for discharging DC fault current to earth of Solar PV plant and provide equipotential bonding for Module Mounting Structure (MMS), SMB Mounting structure, Module Frames etc.

System Requirement for the solar array DC earthing:

Parameter	Requirement
Conductors buried in earth	GS Flat or CCS
Conductors above ground level	GS Flat or CCS
Earth Electrode	32 mm or higher dia MS Rod or Copper bonded Steel rod of dia. not less than 14 mm
Life Expectancy	25 Years
System Fault Level	5 KA for 1 Sec.
Soil Resistivity	Actual as per site conditions
Min. Steel Corrosion	As per IEC 60364-5-54

1. Each Module mounting structure (MMS), SPV Module frames, mounting arrangement for String Monitoring Boxes, Metallic Junction Boxes, Metal frames/Panel, Metallic Pipes of the solar array shall be effectively earthed by two separate and distinct connections to earthing system. Earthing system for solar array shall consist interconnected earth pits electrodes connected by 25X6 GS flat

(Min.) or Copper Clad Steel (CCS) earthing Conductor of size not less than 120 SQMM laid at the depth of 600 MM below the ground. Minimum size of riser conductor to connect the structures to buried earthing conductor and structure to structure in the solar farm shall be 25X3 GS Flat or CCS of Min. 70 SQ MM size.

2. Periphery fencing wherever provided shall be earthed at every 100 meter interval with 25X3 GS flat connected with DC or AC side nearest buried earthing conductor.
3. Earthing conductor for connection to structure and equipment may be kept on the ground below MMS. However, these conductor shall be laid 300 mm below the ground along the pathway and/or crossing the pathway.
4. Equipment and structure in the solar farm shall be earthed in compliance to the IEC 60364-5-54 (Code of Practice for Earthing) and Fiji Electricity Rules/Acts.
5. The Contractor shall furnish the detailed design and calculations for Owner's approval as per IEC 60364-5-54 to determine the number of earth pit and size of earth conductor. However the no. of earth pit electrodes for the DC earthing shall be as per Clause. 2.0 of Chapter A-2
6. Buried earth conductor shall be laid all around periphery of solar array farm. GS flat above the ground for structure earthing shall be connected to the nearest buried conductor or electrode. All the earth electrodes shall be interconnected in single network/mesh and no electrode or group of electrodes shall be isolated/islanded. These electrodes shall be uniformly distributed in the solar farm at maximum practical extent and location of earth electrode shall be approved during detail engineering. A continuous earth path is to be maintained throughout the PV array.
7. Connection of DC earthing system and AC earthing system with location and manner of connection shall be approved during detail engineering. Contractor shall submit the design calculation of earthing system of AC and DC side as standalone (no interconnection) system.
8. Connection of riser to the structures shall be bolted or welded type. Portion of galvanized structure which undergoes welding at site shall be coated with two coats of cold galvanizing and anti-corrosion paint afterwards.
9. Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection, welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding.
10. Each PV Module frame shall be earthed in accordance with module manufacturer guidelines. In case module frame earthing is to be separately provided, it shall be earthed with minimum 2.5 SQMM flexible copper cables with lug at suitable location of module frame. Nos. of PV modules in single loop of earthing connection to module frame shall be as per Module manufacturer recommendation. Both ends of the loop of copper cable for earthing shall be connected with nearest earthed structure or earth conductor.

11. Contractor shall seek owner's approval for connecting solar array earth mesh with any other earth mat/earth grid of the solar PV plant.
12. Size of earth conductor, nos. of earth pits given in this clause is applicable for solar array earthing only. Relevant method and practice of laying of earthing conductor, earth pits and riser not mentioned herewith but given elsewhere in this specification is applicable to solar array earthing also.
13. Inverter functional earthing (Negative earthing, Anti PID Earthing) shall be carried out as per guideline of OEM. Contractor shall submit complete detail of such earthing from OEM and implement the earthing accordingly

14. PLANT ILLUMINATION SYSTEM

This chapter covers supply and installation of suitable illumination system along the approach roads to inverter room and inverter room(s), transformer yard and other facilities inside the plant.

14.1 DESIGN PHILOSOPHY

A comprehensive illumination system shall be provided in the entire project. Each building shall be provided with adequate light fittings,6A/16A socket, fans, etc. Exhaust fans shall also be provided in toilets, battery room, etc

All outdoor lighting system shall be automatically controlled by synchronous timer or photocell. Provision to bypass the timer or photocell shall be provided in the panel.

14.2 LIGHTING SYSTEM DESCRIPTION for CMCS and INVERTER ROOM

Normal AC Lighting System: AC lighting system 415V, 3Phase, 4wire, will be fed from lighting panels Control Board (LPs) which in turn will be fed from the lighting distribution boards (LDBs) of AC Switch board MCC.

Emergency AC Lightning System: The emergency lighting system consisting of 20% of the lights shall be fed from UPS DB or DCDB as per scheme adopted by the EPC bidder. Load of the same has to be considered for UPS/ Battery and charger sizing. Bidder shall provide indoor and outdoor emergency lighting at each inverter room, CMCS, security room and main gate.

14.3 Lighting Fixture, Lamps & Accessories

a) All lighting fixtures and accessories shall be designed for continuous operation for its life under atmospheric conditions existing at site.

b) AC lighting fixtures and accessories shall be suitable for operation on 240 V, AC, 50 Hz supply with supply voltage variation of +/-10%, frequency variation of +/- 5% and combined voltage and frequency variation (absolute sum) of 10% DC lighting fixtures and accessories shall be suitable for operation on 220 V, with variation between 190 V & 240 V.

c) All lighting fixtures shall be complete with lamp(s), lamp holder(s), LED chip assembly, terminal blocks, clamps, locking arrangements, fixing brackets etc. Driver circuit/Control gears shall be provided as applicable / specified. The fixtures shall be fully wired upto terminal block. The internal wiring of the

fixtures shall be done with suitable low smoke halogen free thermo-plastic or silicon rubber insulated or fire retardant PTFE copper conductor wires of suitable size and type. Further fuse protection of suitable rating in input side shall also be provided specifically for LED luminaires. However, the normal cross section of conductor shall be not less than 0.5 Sq. mm and minimum thickness of insulation shall be 0.6 mm. The wiring shall be capable of withstanding the maximum temperature to which it will be subjected under specified service conditions without deterioration and affecting the safety of the luminaire when installed and connected to the supply. All fixing /locking screws, washers, nuts, brackets, studs etc, shall be zinc plated and passivated.

d) All lighting fixtures shall be provided with an external, brass/GI earthing terminal suitable for connecting 14 SWG, GI earthing wire. All metal or metal enclosed parts of the housing and accessories shall be bonded and connected to the earthing terminal as so to ensure satisfactory earthing continuity through out the fixture

e) The lighting fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection

f) The reflectors shall be manufactured from CRCA sheet steel or Aluminium as specified. The aluminium reflectors shall be made of high purity aluminium sheet, polished electrochemically brightened and anodized or proven alternate arrangement of anodizing

g) Starters shall have bi-metal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without use of any tool. Starter shall have brass contacts and radio interference suppressing capacitor.

h) LED luminaires body shall such designed that heat sink/heat dissipating housing shall be mounted outside the overall luminaires fixture housing, and shall be suitably clearing the driver circuit. Further for outdoor type LED luminaires, the exposed heat sink shall be suitably designed to avoid dust/foreign particles accumulation on the same.

i) LED luminaires housing/body shall be pressure die cast aluminium or extruded Aluminium or CRCA as specified alongwith finished powder coating. Care shall be taken in the design that there is no water stagnation anywhere.

15. LED LUMINAIRES:

15.1 Codes And Standards

All standards and codes of practice referred to herein shall be the latest edition including all applicable official amendments & revisions as on date of techno-commercial bid opening. In case of conflict between this specification and those (IEC/ISO codes, standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards & codes.

Standard	Description
IEC/TS 60504	General Lighting. LEDs and LED modules Terms and definitions
IEC 62560	Self-Ballasted LED Lamps for General Lighting Services. Part-1 Safety Requirements.
IEC 62560	Self-Ballasted LED Lamps for General lighting Services. Part-2 Performance Requirements.
IEC 62031	LED modules for General lighting Safety Requirements.
IEC 61347	Lamp control gear Part 2 particular Requirements Section 13 d.c. or a.c. Supplied Electronic control gear for LED modules
IEC 62384	d.c. or a.c. Supplied Electronic control gear for LED modules - Performance Requirements.
IEC 62722	Method of Measurement of Lumen maintenance of Solid-state Light (LED) Sources.
IEC 62471	Method of Electrical and photometric Measurements of Solid State Lighting (LED) Products
IEC 62722	Luminarie Performance
IEC 62471	Photobiological safety of Lamps and Lamp Systems
EN 10130	Cold rolled low carbon steel sheets and strips
IEC 60529	Classification of degree of protection provided by enclosures.
IEC 61000 (Part 3/Sec. 2)	Electro magnetic compatibility (EMC) – Limits for Harmonic emission – THD < 15% (equipment, input current < 16 Amps. per phase).

IEC 60068 (Part 6)	Environment testing: Test Z – AD: composite temperature/humidity cyclic test.
IEC 61347	Lamp control gear: particular requirements for DC or AC supplied electronic control gear for LED modules.
ISO 60092	for LED modules.
ISO 24153	Method for random sampling
IEC 60598	Ingress protection, luminaire performance and safety
IEC 61000-3-2	Total Harmonic Distortion
IEC 61000-4-5	Surge Protection
IES-LM 80 along with TM 21/ IS 16105	Lumen Depreciation and Rated life of LED chip
IES-LM 79 / IS 16106	Luminaire optics and color parameter and electrical parameter

15.2 Led Lighting System

i. LED Luminaires shall be used for the lighting of all the indoor & outdoor areas. However for DC lighting & hazardous areas conventional type luminaires shall be used. In false ceiling area LED luminaires shall be recessed mounting type & in non-false ceiling area the LED luminaires shall be surface mounting type.

ii. The individual lamp wattage for LED shall be upto 3 watt for outdoor type luminaires. However for indoor type luminaires fractional wattage LEDs are also acceptable. The LED chip efficacy shall be min 120 Lm/W. The luminaire efficacy shall not be less than 80 Lm/W. Heat sink/heat dissipation arrangement shall be provided in the luminaires. The LED used in the luminaires shall have colour rendering index (CRI) of Min 70 and 80 for outdoor and indoor luminaires respectively.

iii. Colour designation of LED shall be “cool day light” (min 5700K) type for indoor type LED luminaires. Further for outdoor type luminaires, the colour designation shall be 5000K, except for well glass type LED luminaires, where the colour designation shall be 4000K. The LED luminaires shall have minimum life of 25,000 burning hours with 80% of lumen maintenance at the end of the life.

iv. The beam angle for LED chip for indoor type luminaires shall be 120 degrees. However for highbay & flood light type outdoor luminaires the LED chip with suitable beam angle shall be used to deliver better lumen-output. The

maximum junction temperature of bare LED without heat sink shall be limited to 85 deg C, further the lumen maintenance at this temperature shall be min 90%. The THD of tube light based LED Luminaires shall be less than 20%. For other type of luminaries, it shall be minimum 10%.

v. Further the EMC shall be as per IEC 61000. The power factor of the luminaire shall not be less than 0.9. The marking on luminaire & safety requirements of luminaire shall be as per IS standards. Suitable heat sink/ heat dissipation arrangement, with proper thermal management shall be designed for the luminaires.

vi. Driver Circuit: LED modules and drivers shall be compatible to each other. The LED module driver's ratings and makes shall be as recommended by corresponding LED manufacturer.

vii. LED Drivers may have following control & protections:-

   a. Suitable precision current control of LED.
   b. Open Circuit Protection
   c. Short Circuit Protection
   d. Over Temperature Protection
   e. Overload Protection
   f. Surge Protection

viii. Lighting panels shall be powder coated with color shade RAL9002. Lighting panels shall have IP65 degree of protection (for outdoor panels) and IP-5X for indoor panels (inside buildings).

ix. Wires of different phase shall normally run in separate conduit.

x. Power supply shall be fed from 415 / 240 V normal AC supply through suitable number of conveniently located lighting distribution boards (LDB) and at least one 6/16A, 240V AC universal socket outlet with switch shall be provided in offices, cabins, etc.

xi. Suitable number of 63A, 3ph, 415V AC industrial receptacles shall be provided for welding purposes at one location.

xii. Incandescent lamps may be used only with DC Lighting.

xiii. Electrification of all building shall be carried out as per IEC 60364, and other relevant standards.

xiv. Indoor Lighting fixtures shall generally be controlled from switch boxes of each area not directly from lighting panel. Each switch shall control a maximum of three fixtures.

xv. All luminaries and their accessories and components shall be of type readily replaceable by available in Fiji market.

Following test reports to be submitted for LED chip/LED luminaires:

a) LED parameters like Lumen per watt, CRI, Beam angle from manufacturer.
b) LM 80/ report.
c) LM 79/ report

15.3 JUNCTION BOXES, CONDUITS, FITTING & ACCESSORIES

i. Junction box for indoor lighting shall be made of fire retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type.
ii. Junction boxes for street lighting poles and lighting mast if applicable , shall be deep drawn or fabricated type made of min. 1.6 mm thick CRCA Sheet. The box shall be hot dip galvanized. The degree of protection shall be IP55.
iii. All switches and receptacles upto 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox & plate.
iv. Conduits, Pipes and Accessories:
v. Heavy duty PVC conduits conforming to IEC 60614 along with various accessories shall be used for indoor wiring in the buildings. These conduits shall be concealed in the wall/floor/roof. However, in PEB's, conduits can be fixed on surface.
vi. Pull out boxes shall be provided at suitable interval in a conduit run .Boxes shall be suitable for mounting on Walls, Columns, etc. Pull-out boxes shall have cover with screw. Pull out boxes used outdoor shall be weather proof type suitable for IP: 65 degree of protection and those used indoor shall be suitable for IP: 5X degree of protection.

15.4 LIGHTING WIRES

i. Lighting wires shall be 1100 V grade, light duty PVC insulated unsheathed, stranded copper/aluminium wire for fixed wiring installation.
ii. Colour of the PVC insulation of wires shall be Red, Yellow, Blue and Black for R,Y,B phases & neutral, respectively and white & grey for DC positive & DC negative circuits, respectively.
iii. Minimum size of wire shall not be less than 1.5 sqmm for copper.

15.5 LIGHTING POLES

The Street Light system and peripheral lighting shall be designed generally in line with design guidelines. Height of the poles should be chosen so as not to affect working of Solar panels. The poles shall be hot-dip galvanized as per relevant ISO 1461The average coating thickness of galvanizing shall be min. 70 micron. The System shall be capable of withstanding the appropriate wind load etc. as per ISO 4354 considering prevailing soil/ site condition considering all accessories mounting on pole.

The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB. Lighting shall be provided along boundary/periphery and at roads connecting Boundary Gate to strategic locations like CMCS/Switchyard (Minimum 10 Lux).

Hot dipped Galvanized hexagonal/Octagonal lighting pole with inbuilt JB shall also be acceptable

15.6 EARTHING

Lighting panels, etc. shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, fans, single phase receptacles etc. shall be earthed by means of separate earth continuity conductor. The earth continuity conductor 14 SWG GI wire shall be run along with each conduit run. Cable armours shall be connected to earthing system at both the ends.

15.7 AVERAGE ILLUMINATION LEVEL

Location	Average Illumination Level (Lux)	Type of Fixture
Control Room	300	LED Luminaries
Storeroom	200	LED Luminaries
Switchgear Room	150	LED Luminaries
Inverter Room	150	LED Luminaries
Street lighting-Roads Cl 7. above	10	LED Luminaries
Yard/ Substation/MCS etc	20(general) 50(on strategic equipment)	LED Luminaries

Alternately Vendor may offer technically superior and proven product subject to approval of employer.

16. AUXILIARY POWER SUPPLY SYSTEM

16.1 GENERAL

i. Auxiliary power supply arrangement shall be in line with tender SLD. Each Inverter Room/local pooling/sub-pooling/CMCS room shall have its own auxiliary power supply system comprising of AC distribution board (ACDB) which shall be fed from two power sources with auto changeover switch. ACDB in CMCS room shall have two incomer (100% rated) fed from two different sources.
Following consideration shall be taken while arriving kVA capacity of auxiliary transformer:
- 25 % future load margin.
- The minimum kVA capacity of auxiliary transformer requirement shall be 50kVA.

ii. All non-critical auxiliary loads shall be fed directly from ACDB. However, emergency, and important load shall be fed from suitable sized Uninterrupted Power Supply (UPS) or Battery system. Input AC supply for Uninterrupted Power Supply (UPS) and Battery Charger shall be fed from ACDB. Bidder shall consider the following one of the supply options for feeding different equipment loads:

Sl No	Equipment Name	Option-1 ACDB	Option-2 UPS AC	Option-3 Battery DC supply
1.	SCADA including remote RTU/IO panel		✓	✓
2.	SCADA HMI		✓	✓
3.	Data logger		✓	✓
4.	Fire Detection /Alarm Panel		✓	✓
5.	Emergency Lighting		✓	✓
6.	CCTV (if applicable)		✓	✓
7.	HMI of SCADA		✓	✓
8.	Inverter's Auxiliary supply (if applicable)		✓	✓
9.	Energy Meter/MFM		✓	✓
10.	Sub and Local Pooling Switchgear control & protection		✓	✓
11.	Main Pooling Switchgear (CMCS) control & protection			✓
12.	Switchgear spring charging motor		✓	✓

13.	switchgear space heater	✓		
14.	Illumination, Fan supply etc	✓		
15.	Module washing system	✓		
16.	Other non-critical auxiliary loads	✓		
17.	All electrical loads of CMCS Building, Gate complex, security cabin, maintenance building and storeroom.	✓		

iii. For inverter stations and sub-pooling systems, UPS system shall comprise of 1 x 100% UPS with 30 minutes backup. For CMCS, UPS system shall comprise of 2 x 100% UPS with 30 minutes backup for each. Each UPS shall consist of 1x100% charger and inverter, 1 x 100% Battery bank for providing required backup as above. Bypass Line static switch, manual bypass switch, 1 x 100% UPSDB, and other necessary Protective devices and accessories. In place of UPS, bidder can provide DC supply system (1 x 100% Battery with Charger system for inverter stations/sub-pooling systems and 2x 100% system for CMCS) with backup as indicated as above, if the auxiliary power supply requirement of the loads is in DC.

iv. Each Battery with charger system shall consist of 1 x 100% charger and 1 x 100% Battery bank for required back up and 1 x 100% DCDB, and other necessary protective devices and accessories. DC supply system voltage shall be 12V or above upto 220V DC.

v. The rated AC output capacity shall be taken for UPS battery size calculation. However, the minimum UPS rating shall be 2KVA and the battery sizing shall be calculated on a minimum load of 1 KW (DC) for required backup. All UPS having rating 5KVA or more shall have three phase input.

vi. The Bidder can provide alternate arrangement with suitable redundancies such as power pack with required backup for switchgears/RMUs located at local pooling/inverter station.

vii. Solar Plant Main Pooling Switchgear shall be powered from 2X100% DC supply system. Each DC supply system shall consist of 1x100% charger, 1 x 100% station Battery bank rated 110V/220VDC (+10%,-20%) for providing minimum 30 minutes backup and DC switchgear. In case UPS fed from above DC supply system, in that case separate DC system for UPS is not required.

viii. For CMCS, each UPSDB shall have two incomers fed from two separate UPS and one bus coupler. Similarly, each DCDB/DC switchgear shall have two incomers fed from two separate Battery-Charger and one bus-coupler.

ix. DC system shall be design in such way that it is possible isolate the battery and charger for boost charging of batteries, while corresponding DC switchgear

section shall be capable of being in service and continue to supply the DC load by closing of bus coupler.

x. Bidder shall submit configuration diagram, power supply distribution scheme, single line diagram and data sheets, all calculations such as Rectifier Modules/UPS Charger/Inverter rating calculations, battery sizing calculation etc. for UPS, Battery Charger & Battery system during detailed engineering stage for employer's review and approval.

xi. Size and rating of UPS, Battery Charger and Battery shall be finalized during details engineering stage. Following shall be considered for sizing calculation;

a) UPS load power factor shall be taken as 0.8 lagging.
b) UPS efficiency shall be taken as per actual.
c) UPS and charger design margin shall be taken 10% at 50 deg C.
d) IEEE-485 standard shall be followed for sizing calculation of Lead Acid Batteries and IEEE-1115 standard shall be followed for sizing calculation of Nickel-Cadmium batteries.
e) For Battery sizing calculation, lowest electrolyte temperature shall be taken as 5 deg C more than the minimum ambient temperature or 15 deg cel whichever is lower, with Temperature correction factors as per relevant standards.
f) Batteries aging factor shall be taken as 1.25 and design margin factor shall be taken as 1.10.

16.2 UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM

xii. The UPS shall have an overload capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 seconds. The overall efficiency of UPS shall be at least 80% on full load.

xiii. The UPS system shall be capable of operating without D.C. battery in circuit under all conditions of load and the performance of various components of UPS like inverter, charger, static switch etc. shall be guaranteed without the battery in circuit.

xiv. For UPS capacity 5 kVA or more, in addition to indications/display on UPS panel, important alarms along with important analog signal shall also be provided for use in SCADA. For UPS capacity less than 5 kVA bidder shall provide status, common alarm, and trip DI (soft or hard) signal to SCADA

xv. The UPS chargers shall be self-regulating, solid state silicon controlled, full-wave rectifier type designed for single and parallel operation with battery and shall have automatic voltage regulators for close voltage stability even when AC supply voltage fluctuates. The charger should be capable to fully charge the required batteries as well as supply the full rated load through inverter. The charger shall be

able to re-charge the fully discharge battery within 8 hours. The charger shall be design for input supply variation of ± 10% and frequency variation of ± 5%. Charger design shall ensure that there is no component failure due to fluctuations of input supply or loss of supply and restoration. The detailed specification for the battery charger for UPS rating of 5kVA and above has been mentioned in the battery charger section below in this specification.

xvi. The UPS inverter shall be of continuous duty, solid state type using proven Pulse Width Modulation (PWM)/Quasi square wave/step wave technique. Ferro-resonant types Inverters are not acceptable. The nominal voltage output shall be 230 Volts single phase, 50 Hz. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, etc. The total harmonic content shall be 5% maximum and content of any single harmonic shall be 3% maximum.

xvii. The static switch shall be provided to perform the function of transferring UPS loads automatically without any break from faulty inverter to standby AC source. Manual bypass switch shall be employed for isolating the UPS during maintenance.

xviii. Contractor has the option of supplying either Nickel Cadmium type batteries or Lead Acid Plante type batteries. The detailed specification for the batteries has been mentioned in the battery and charger section below in this specification.

xix. Equipment enclosures shall match and line up in assemblies of freestanding floor mounted cabinets designed for indoor service.

xx. Individual enclosure shall be ventilated switchboard type fabricated from not less than 1.6-mm thick sheet steel. Enclosures shall be furnished with concealed hinges. Front and rear doors shall be designed to permit easy access to all components for maintenance or replacement. The enclosures shall be reinforced with formed steel members as required to form a rigid self-supporting structure. Doors shall have three point latches.

xxi. Adequate ventilating louvers and enclosure top panels shall be included. All vent openings shall be covered with corrosion resistant fine screen coverings.

xxii. The cabinets shall be IP-55 protection class for indoor application and IP65 or better for outdoor application.

xxiii. The temperature rise inside all the cabinets/enclosures shall not exceed 10 deg.C above ambient temperature.

xxiv. The Contractor shall also carry out the site tests on UPS as required to be conducted as a standard practice of the UPS manufacture or deemed necessary by the Employer and mutually agreed between the Contractor and the Employer.

xxv. One set of tools shall be provided for maintenance and testing purposes.

16.3 BATTERY CHARGER

The Battery Charger shall operate on 240 V Single-Phase AC, 50 Hz or 415 V Three-Phase AC, 50 Hz, and an instruction card shall be provided for each set. Suitable means shall be provided, including the use of diodes, to prevent excessive voltage that may cause damage to connected equipment while the battery is being charged.

Each battery charger and battery bank shall be capable of delivering the entire rated load for 10 hours, and under all circumstances, the DC load voltage shall not drop below 90% of the nominal 110 V DC after the battery has supplied the full continuous load for 10 hours. The battery under boost charge and the corresponding charger shall be disconnected from the distribution board through selector switches and power contactors. The batteries shall be protected against over-discharge. Earth fault detectors shall be provided for each DC busbar. Metering circuits shall be provided and wired for remote indication and SCADA monitoring.

Separate identical 100% duty chargers, equipped with both boost and float charging facilities, shall be provided for each battery. Each charger unit shall be suitable for supplying the initial charging requirements, boost charging the battery following an emergency discharge, and supplying the maximum load while operating on float charge. Each charger shall be housed in a separate cubicle with a minimum degree of protection of IP56. The equipment shall comply with the corrosion protection requirements specified elsewhere in this Specification. For wiring, contactors, terminals, and associated accessories, reference shall be made to the relevant sections of the Specification. The chargers shall be provided with natural ventilation. Forced ventilation shall not be acceptable. Cubicle dimensions and general arrangements shall be coordinated with the DC distribution panels, as the equipment may be installed within the same room.

Switch Mode (N+1) chargers with SCADA communication using DNP3.0 protocol over Ethernet shall be provided. EFL is embarking on condition monitoring of battery banks using intelligent chargers; therefore, Switch Mode (N+1) chargers with SCADA DNP3.0 communication capability are required.

Each Battery Charging Equipment shall comply with the requirements of BS EN 60146-1-1 and BS EN 60146-1-3 (IEC 60146).

The charger system, housed in a single cabinet, shall include:

- Rectifier modules
- Contactor coils

- Current transducers (minirack type)
- CT interface cables suitable for operation with 110 V DC
- Necessary software and training
- Battery breaker
- All auxiliary contacts
- Battery Cell Condition Monitoring Unit
- Site Monitoring Module
- Vented blanking panel

All details and necessary information regarding the above shall be provided for technical evaluation.

The system shall include the following minimum features:

- Communication Protocol: DNP3.0
- Ethernet communication with provision for fibre-optic connectivity
- Current and voltage monitoring for each cell
- Ability to perform automated battery discharge testing
- Temperature-compensated charging
- N+1 switch mode charger configuration

Battery chargers shall be of high efficiency, with fast control response and low output ripple, even when the battery is not connected. The chargers shall be rated for continuous output short-circuit operation and shall be of solid-state, full-wave, fully controlled design using silicon rectifiers with N+1 redundancy. They shall be complete with all switches, miniature circuit breakers (MCBs), fuses, contactors, and indicating instruments.

The output voltage shall be regulated from no-load to 100% load, even with ±10% variation in AC input voltage and ±5% variation in supply frequency.

The battery chargers shall be of the constant-voltage float type, each provided with boost charging facilities. Each charger shall be capable of maintaining the battery in a fully charged condition while simultaneously supplying the connected DC load under all specified operating conditions.

16.4 BATTERY: NICKEL-CADMIUM BATTERY

16.4.1 Battery Parameter

1	Battery Voltage	To be decided during Detail Engineering
2	No. of Cells	To be decided during Detail Engineering
3	Battery type	Nickel-Cadmium
4	Nominal discharge Voltage per Cell	1.2
5	Float voltage	1.42V/Cell

Batteries should be suitable for continuous operation for the maximum ambient temperature as defined in technical parameters.

16.4.2 Codes And Standards

All standards, specifications and codes of practice referred to herein, shall be the latest editions including all applicable official amendments and revisions as on date of opening of techno-commercial bid. In case of conflict between this specification and those (IEC/ISO/ASTM codes, Standards etc.) referred to herein, the former shall prevail. All works shall be carried out as per the following standards and codes:

IEC 60623/	Specification for vented type Nickel Cadmium Batteries.
ASTM C897	Quality tolerances for water for storage batteries
IEC 60993	Electrolyte for vented Nickel-Cadmium cells
Fiji electricity rules	
Fiji electricity acts	

Equipment complying with other internationally accepted standards such as IEC., BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.

DC Batteries shall be stationary Nickel Cadmium Pocket plate type conforming to AS IEC 60623:2022. The batteries shall be high/medium discharge performance type suitable for the backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

DC batteries shall be suitable for standby duty. The batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42 V/cell.

16.4.3 Construction Features:

a) Containers

Containers shall be made of polypropylene plastic material. Containers shall be robust, heat resistance, leak proof, nonabsorbent, alkali resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of translucent containers.

Vent Plugs

Vent plugs shall be provided in each cells. They shall be anti-splash type, having more than one exit hole shall allow the gases to escape freely but shall prevent alkali from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition, the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte samples.

b) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IEC 623. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative terminal posts shall be clearly marked.

c) Sediment Space

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

d) Electrolyte

The electrolyte shall be prepared from battery grade potassium hydroxide conforming to IEC 60993. The cells can be shipped either in charged condition or in dry condition. Necessary electrolyte for make-up shall be supplied separately.

e) Connectors and Fasteners

Nickel plated copper connectors shall be used for connecting adjacent cells and PVC insulated flexible copper cables shall be used for inter-row / inter-tier / inter-bank connections. Bolts, nuts and washers shall be Stainless Steel / Nickel coated steel to prevent corrosion. The thickness of Nickel coating of connectors should be not less

than 0.02 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds.

f) Battery racks

Mild steel racks for all the batteries shall be provided. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries racks and supports for cable termination shall be coated with three (3) coats of anti-alkali paint of approved shade. Name plates, resistant to alkali, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

g) Test

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest INTERNATIONAL STANDARDS (for all applicable tests for containers).

The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.

16.5 BATTERY: LEAD –ACID PLANTE BATTERY

16.5.1 Battery Parameter

a)	Battery Voltage	To be decide during Detail Engineering
b)	No. of Cells	To be decide during Detail Engineering
c)	Battery type	Stationary Lead Acid Plante
d)	Nominal discharge voltage per cell	2.0V
e)	Float Voltage	2.25V/Cell

16.5.2 Codes And Standards

IEC 60896	**Stationary Lead-Acid Batteries**
ISO 3696	Specification for water for storage batteries
IEC 896-2	Specification for rubber & plastic containers for lead acid storage batteries.

IEC 60896	Specification for stationary cells and batteries, lead acid type (with plante positive plates).
IEC 60896	General requirements and methods of tests for lead acid storage batteries.
IEC 62882	Specification for synthetic separators for lead acid batteries.

Equipment complying with other internationally accepted standards such as IEC, BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.

DC Batteries shall be stationary lead acid Plante positive plate type conforming to IEC 60896. The batteries shall be high/medium discharge performance type suitable for the backup time as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

DC Batteries shall be suitable for standby duty. The Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under continuous float operations and occasional discharges. The batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.25 V/cell.

16.5.3 Construction Features:

a) Containers

Containers shall be made of transparent glass, hard rubber, suitable robust, heat resistance, leak proof, non-absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of transparent containers. Float type level indicator shall be provided in case of opaque containers. The stem portion of the float should be long enough to prevent falling of the float inside the container even if there is no electrolyte in the container. The marking for the electrolyte level should be for the upper and lower limits. The material of level indicator shall be acid proof and oxidation proof. Container shall be closed/sealed lid type. Lid and sealing compound shall be non-cracking type. The container made of hard rubber and plastics shall be type tested as per IEC 60896-2.

The pole sealing arrangement should be such that no acid particle get entrapped due to acid creep as a result of capillary action, and it should be possible to remove and refix the sealing to carry out the maintenance.

b) Vent Plugs

Vent plugs shall be provided in each cell. They shall be ant splash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition, the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte sample.

c) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IEC 60896 as applicable.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative post shall be clearly marked.

d) Sediment Space

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

e) Cell Insulator

Each cell shall be separately supported on PVC/porcelain/hard rubber insulators fixed on the racks with adequate clearance between adjacent cells. Minimum distance between adjacent cells shall be more than the bulge allowed for two cells in accordance with International Standard.

f) Electrolyte

The electrolyte shall be prepared from battery grade sulphuric acid conforming to ASTM B6 and distilled water conforming to IEC 62877. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately.

g) Connectors and Fasteners

Lead or Lead coated copper connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. The thickness of lead-coating of connectors should not be less than 0.025 mm. The lead coating thickness shall be measured in accordance with APPENDIX F of

ISO 2560 (latest edition). All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds. End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC insulation. Necessary supports and lugs for termination of these cables on batteries shall also be supplied by the contractor.

h) Battery racks

Wooden racks for all the batteries shall be provided. These racks shall be made of good quality first class seasoned teak wood in line with EFL specification. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries rack and wooden support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor. Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

i) Test

The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest BS 143 & BS 1256 (for rubber & plastic containers for lead-acid storage batteries)/IEC 60228 (for lead-acid plante batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier. Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.

16.6 Auxiliary equipment

Manual discharge resistance bank suitable for each type of battery bank of UPS/Battery Charger has to be provided by contractor.

Following shall be provided (as per applicability) for maintenance purpose		
a	Hydrometers	2 Nos.
b	Set of hydrometer syringes suitable for the vent holes in different cells	2 Nos.
c	Thermometer for measuring electrolyte	2 Nos.

	temperature	
d	Specific gravity correction chart	2 Nos.
e	Wall mounting type holder made of teak wood for hydrometer & thermometer	2 Nos.
f	Cell testing voltmeter (3-0-3 V)	2 Nos.
g	Alkali mixing jar	2 Nos.
h	Rubber aprons	5 Nos.
i	Pair of rubber gloves	
j	Set of spanners	5 Nos.
k	No smoking notice for each battery room	2 Nos.
l	Goggles (industrial)	2 Nos.
m	Instruction card	2 Nos.
n	Temperature indicator	1 No. per room
o	Cell lifting facility	1 Set per room

Following shall be taken as minimum load value for sizing calculation of UPS/Battery Charger/Battery system. However, Bidder needs to provide the details auxiliary power rating of each individual equipment. & any other load apart from below required for completion of the system is also in the scope of the bidder.

Sl No	Description	Rated Power in Watt	Remarks
1	HT Switchgear VCB Panel		
(i)	Closing Coil	Actual as per datasheet	First minute load
(ii)	Tripping Coil	Actual as per datasheet	Last minute load
(iii)	Spring Charging Motor	Actual as per datasheet	First minute load
(iv)	Numerical Relay	20	Continuous load

(v)	Auxiliary Relays	20 (total)	Continuous load
(vi)	LED Indication Lamps	10 (total)	Continuous load
(vii)	Misc. load	20 (total)	Continuous load
2	Inverter (if applicable)	300	Continuous load
3	SCADA panel at CMCS	2000	Continuous load
4	SCADA HMI including LED Display and Printer	500	Continuous load
5	SCADA RTU panel at PEB	400	Continuous load
6	Transformer N2 Injection unit at PEB (if applicable)	100	Continuous load
7	Fire Alarm Panel at CMCS	300	Continuous load
8	Fire Alarm Panel at PEB	200	Continuous load
9	WMS	100	Continuous load
10	Emergency Load (light + Fan) at CMCS	300	Continuous load
11	Emergency Load at PEB	100	Continuous load

Following shall be considered for main pooling/final pooling HT switchgear as a minimum.
(i) Per switchboard only one panel spring charging motor load shall be considered.
(ii) All outgoing and tie feeder panel trip coil load (subject to Minimum 3 Nos) shall be considered.
(iii) All outgoing feeders+ Aux transformer feeders+ 50% of incomer panel closing coil load shall be considered.

Following shall be considered for inverter station HT switchgear/RMU.
i) Per switchboard only one panel spring charging motor load shall be considered.
(ii) All panel trip coil and close coil load shall be considered.

16.7 SITE TESTS

The contractor shall carry out the following site tests as applicable on UPS, Battery Charger and Battery system. However, any other site test is required to be conducted as a standard practice of the OEM or deemed necessary by the employer and mutually agreed between the contractor and the employer, the same shall also be carried out.

16.7.1 Light Load Test

This test is carried out to verify that the UPS/Battery Charger is correctly connected and all functions operate properly. The load applied is limited to some percent of rated value. The following points should be checked:

- Output voltage, frequency and the correct operation of meters;
- Operation of all control switches and other means to put units into operation.
- Functioning of protective and warning devices.

16.7.2 A. C. Input Failure Test

The test is performed in UPS/Battery Charger with a fully charged battery and is carried out by tripping input supply feeder or may be simulated by switching off all rectifiers and bypass feeder as at the same time. Output voltage variations are to be checked for specified limits with an oscilloscope/Recorder.

16.7.3 A. C. Input Return Test

AC input return test is performed in UPS/Battery Charger by closing AC input supply feeder, or is simulated by energizing rectifiers. Proper operation of rectifier starting and voltage and frequency variations are to be observed. This test is normally performed with a fully or partially charged battery.

16.7.4 Auto changeover Test

This test shall be carried out in UPS ACDB fed from two separate UPS system. Auto changeover of one UPS source to standby UPS to be check by tripping the active UPS manually or by simulation condition. This test shall be check as per approved auto changeover logic.

16.7.5 Transfer Test (for UPS)

This test is applicable for UPS with bypass, particularly in the case of an electronic bypass switch. Transients shall be measured during load transfer to bypass caused by a simulated fault and load retransfer after clearing of the fault.

16.7.6 Full load test

Load tests are performed by connecting the actual load to the UPS/Charger output. Load tests are necessary for testing output voltage and frequency, rated stored energy, recharge time, ventilation, and temperature.

16.7.7 Rated Stored Energy Time (Battery test)

This test is a load test to prove the actual possible time of battery operation. If rated load is not available in the case of large UPS/Battery charger, it is possible to apply a partial load to check the actual battery discharge characteristics and compare these with characteristics specified by the battery manufacturer. Discharge time with rated load shall then be calculated. The test shall be performed with a fully charged battery and also may be done under other battery conditions to be specified, if so agreed. Active power output of the UPS/Battery Charger and the battery voltage shall be recorded during the test. Since new batteries often do not provide full capacity during a starting up period, the discharge test may be repeated after a reasonable recharge time if the original test has failed.

16.7.8 Rated Restored Energy Time

Restored energy depends on the charging capacity of the rectifiers and the battery characteristics. If a certain recharging rate is specified, it shall be provided by repeating the discharge test after the specified charging period.

16.7.9 Battery Ripple Current

If battery ripple currents are specified, then the ripple current which depends on UPS operation shall be checked under normal operating conditions. Rough measuring methods are sufficient.

17. LIGHTNING PROTECTION SYSTEM

17.1 GENERAL REQUIRMENTS

This specification is intended to outline the requirement of external lightning protection (ELP/Lightning protection) for Solar array (DC) side and AC Power block side of Solar PV Project. It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of external lightning protection system meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of earthling system for safe and satisfactory operation of the plant shall be included under scope of the bidder.

17.1.1 LIGHTNING PROTECTION DESIGN REQUIRMENT

The object of a lightning protection system is to protect buildings/structure and equipment from direct lightning strikes, potential fire as well as the effects of injected lightning currents (non-incentive flash). It consists of termination systems for direct lightning, down conductors and an earth-termination system.

Care must be taken for while designing the lightning protection that surges are prevented in the electrical system to reduce failure of electrical and electronic equipment.

17.1.2 CODES AND STANDARD

The equipment/product furnished for earthing system shall meet the requirements of all the applicable relevant National/International codes and standards or their latest amendment Codes and Standards. Product certification has to be CE/UL/BIS/TUV or equivalent. The relevant codes and standard for earthing system are tabulated below.

IEC 62305	PROTECTION AGAINST LIGHTNING
IEEE: 80	IEEE guide for safety in AC substation grounding
IEEE: 837	Standard for qualifying permanent connections used in substation grounding
ISO 1461	Recommended practice for hot dip galvanizing of iron & steel

ISO 1461	Method for testing uniformity of coating on zinc coated articles
ISO 3574	Cold rolled low carbon steel sheets and strips
ISO 1461	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
EN 10025-2	HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL — SPECIFICATION
ISO 4435	Precast Concrete Pipes (With and Without Reinforcement)
UL-467	Grounding and Bonding Equipment
IEC 62561-7	Requirements for earthing enhancing compounds
NFC 17 -102	Early streamer emission lightning protection Systems

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (codes and standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the above standards/ codes as applicable.
The lightning protection system includes lightning terminal, Down conductor, test ink, earth electrode, installation of lightning terminal, down conductor and earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with lightning terminal.

17.2 DOWN CONDUCTORS

i. Down conductors shall be as short and straight as practicable and shall follow a direct path to earth electrode.
ii. Each down conductor shall be provided with a test link at 1000 mm above ground level for testing but it shall be in accessible to interference. No connections other than the one direct to an earth electrode shall be made below a test point.
iii. All joints in the down conductors shall be welded type.
iv. Down conductors shall be cleated on outer side of building wall, at 750 mm interval or welded to outside building columns at 1000 mm interval.

v. Lightning conductor on roof shall not be directly cleated on surface of roof. Supporting blocks of PCC/insulating compound shall be used for conductor fixing at an interval of 1500 mm.
vi. All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.
vii. Lightning conductors shall not pass through or run inside GI Conduits.
viii. Testing link shall be made of galvanized steel of size 25x 6mm.
ix. Hazardous areas handling inflammable/explosive materials and associated storage areas shall be protected by a system of aerial earths, oxide layer or foreign material.

17.3 LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY

a) Codes and Standard
IEC 62305: PROTECTION AGAINST LIGHTNING
NF C 17-102 : Lightning Protection with Early Streamer Air Termination Rod

b) Complete Solar Array with associated structure shall be protected from Direct Lightning Stroke. Lightning Protection for solar array shall be achieved with any or both of the following two systems as per specification provided in the following section.

- Single Rod Air Terminal (Faraday Rods)
- Early Streamer Emission (ESE) Air Terminal
- Suitable earthling and equipotential bonding shall be ensured for the lightning protection Air Terminal as per applicable standard/Equipment manufacturer guidelines.
- Current carrying parts and accessories such as clamps, fasteners, down conductor, Test links and earth termination etc. shall be preferably procured from OEM of Air Terminals if it is supplied by them as part of lighting protection system.

c) LIGHTNING PROTECTION SYSTEM FOR SOLAR ARRAY WITH E.S.E AIR TERMINAL

- Solar array shall be protected from direct lightning stroke with Early Streamer Emission air terminal in accordance with NF-C 17-102.
- Location and layout of ESE terminal shall be in such a manner that it cast no shadow on the PV Modules during 08:30 AM to 04:30 PM. Any minor changes in timings shall be reviewed during detailed engineering stage, provided the proposal is acceptable to PV Module manufacturer.
- Number and location of ESE air terminal shall be decided during detail engineering. For this purpose, design calculation considering protection level IV

(minimum) and AUTOCAD drawing of the layout of ESE terminal shall be submitted to EFL for approval.

- ESE air terminal shall be type tested as per Annexure- C of NF C 17-102 (Latest Revision) in the manner as mentioned in the standard.
- ESE Air terminal shall be supplied with test link, counter, down-conductor, Two earth pits, support mast and accessories required for completeness for ESE Lightning protection system.
- Owner shall test ESE terminal (Each terminal/Sample basis) before installation with suitable instrument for functionality of terminal. Vendor shall replace the terminal free of cost if found defective.
- Support mast for ESE Air terminal shall be heavy duty hot dip galvanized material and shall be suitable to withstand dynamic and static forces acting on it without failure. Foundation for the mast shall be M20 Grade concrete or better with minimum depth of 1200 MM.

17.4 LIGHTNING PROTECTION SYSTEM FOR BUILDING AND ENCLOSURE

- Contractor shall provide lightning protection for Inverter room/shed/shelter/enclosure, main control room, Switchgear Room/shed/shelter and similar housing per IEC 62305.
- ESE Air Terminal shall not be used for lightning protection of Metering yard/Switchyard.

18. METERING SYSTEM

18.1 GENERAL

This Specification covers the general requirements of the design, engineering, manufacturing, assembly and inspection & testing of CT/ VT connected, Programmable Static Poly Phase Energy Meter (herein after referred to as "The Meter" in this specification) of Accuracy Class 0.2S with Time of Day Reading Facility and option for remote reading. The meters shall be used for commercial/ tariff metering for inter License power flows/ bulk consumers application and suitable for operation on either MV or HV application as specified.

The meter shall have wide secondary current range support i.e. same meter shall be put up for 1A or 5A rating as per field availability of CT's. Meter required to be commissioned at each substation shall be of 3 phase 4 wire or 3 phase 3 wire. Preferred energy meter is Shark 200 V6.

The Meter shall have the facility to programme and read from a PC connected to the meter using USB and Optical port. Meter shall also have the communication facility to take the meter reading and any other data remotely via a data communication network. The communication modules, including accessories required at both local and remote ends and software for remote meter reading shall be supplied with the meter. It shall be possible to replace the communication unit at site without breaking the meter calibration seals.

Following items shall be supplied by the Bidder.

- The meter as specified
- Communication module for the meter including accessories
- Communication module for the PC includes accessories. PC software and accessories including optical cable for local configuration

18.2 APPLICABLE STANDARDS

The equipment and components supplied shall be designed manufactured and tested in accordance with the latest editions/amendments of the Standards specified below. However, the EFL Specification shall supersede these standards in the event there is a discrepancy.

Sr No.	Standard No.	Title
A	IEC 62052-11	Electricity metering equipment (AC) – General requirements, tests, and test conditions- Part 11: Metering equipment
B	IEC 62052-21	Electricity metering equipment (AC) –General requirements, tests and test conditions – Part 21: Tariff and load control equipment
C	IEC 62053-22	Electricity metering equipment (AC) Particular requirements - Part 22: Static meters for active energy (classes 0.2S and 0.5)
D	IEC 62053-23	Electricity metering equipment (AC) Particular requirements -Part 23: Static meters for reactive energy (classes 2 and 3)
E	IEC 62058-11	Electricity metering equipment (A.C) – Acceptance inspection-Part 11: General acceptance inspection methods
F	IEC 62058-31	Electricity metering equipment (A.C) - Acceptance inspection-Part 31: Particular requirements for static meters for active energy (Class 0.2S, 0.5S, 1 and 2)
G	IEC 62056-21	Electricity metering - Data exchange for meter reading, tariff and load control Part 21: Direct local data exchange
H	IEC 62056-42	Electricity metering - Data exchange for meter reading, tariff and load control Part 42: Physical layer services and procedures for connection-oriented asynchronous data exchange
I	IEC 62056-4-7	Electricity metering data exchange –The DLMS/COSEM suite – Part 4-7: DLMS/COSEM transport layer for IP networks
J	IEC 62056-52	Electricity metering - Data exchange for meter reading, tariff and load control Part 52: Communication protocols management distribution line message specification (DLMS) server

K	IEC 62056-5-3	Electricity metering data exchange –The DLMS/COSEM suite – Part 5-3: DLMS/COSEM application layer
L	IEC 62056-6-1	Electricity metering data exchange –The DLMS/COSEM suite – Part 6-1: Object Identification System (OBIS)
M	IEC 62056-6-2	Electricity metering data exchange – The DLMS/COSEM suite – Part 6-2: COSEM interface classes
N	IEC 60529	Degrees of protection provided by enclosures (IP code)
O	ISO 75	Plastics — Determination of temperature of deflection under load
P	ISO 9001	Quality management systems -Requirements
Q	ISO/IEC: 17025	General requirements for the competence of testing and calibration laboratories

18.3 METER REQUIREMENT

18.3.1 Standard Parameters

i)	**Reference Voltage**	**110 V AC**
ii)	Standard Rated Current	**1 Amp**
iii)	Maximum Current	**1.2 × standard rated current**
iv)	Auxiliary Supply	**60-240 V AC/DC**
v)	Frequency	**50Hz**
vi)	**Wiring Configuration**	**Shall be capable of wiring 3P4W**

18.3.2 Measurement

The meter shall be suitable for full power factor range from zero (lagging) through unity to zero (leading). The meter shall work as an active energy import and export meter along with reactive (lag and lead) meter. The energy measurement should be true four quadrant type.
The Meter shall be of programmable type suitable for recording active energy consumption in kWh/MWh, reactive energy consumption in kvarh/Mvarh, average demand in kVA/MVA and kW/MW. The accuracy class of the meter shall be class 0.2S for Active energy and class 2 or less for reactive energy.
The Meter shall be suitable for Time-of Day (minimum of 6 intervals), Import-Export Energy Metering. The Meter shall have provisions to change the time of day tariff in the field and shall have facility to programme for a minimum of six (06) times of day tariffs. Export Energy shall be measured as positive and shall be able to re-programme depending upon the necessity.
The Meter shall record the monthly cumulative consumption of active energy and reactive energy separately. It also shall record the maximum of average apparent and active power demand over a demand integration period of fifteen (15) minutes every month.

18.3.3 Operation:

The Meters shall detect and record CT polarity reversal as an event with date and time of such occurrence and restoration with phase identification. The Meter shall record the consumption in a separate register with TOD which shall be displayed when required in case polarities are reversed or shall record the consumption correctly even under polarity reversed.
The Meter shall be capable of detecting and recording occurrence of missing voltages and shall display the details of Power disconnections, tampering attempts, power restorations and other details such as time and date of such occurrences.
The Meter shall record the consumption accurately irrespective of the phase sequence of supply.

18.3.4 Mounting:

The Meter shall be of the indoor type surface mounting, having terminals at the bottom connected with the secondary side of outdoor current and voltage transformers and mounted in suitable panel/ cubicles.

18.3.5 Maximum Demand:

Facilities shall be provided to reset the maximum demand automatically at a preset date and time as well as manually. It shall be possible to disable the MD reset button

and to seal it, if required. It shall also be possible to programme, download data and reset the maximum demand remotely through software running on a PC compatible on latest version of Windows.

18.3.6 Security:

The meter shall have necessary security facilities to prevent unauthorized meter parameter changes (password protected). It shall include minimum two levels of authorizations in order to read and programme meters. Facilities shall be provided to modify the password at the meter programming level. A list of set passwords shall be provided with the samples

18.3.7 Flashing Light Indication

Minimum two flashing light indications shall be available on the front face of the Meter which acts as an activity indicator, one LED which blinks analogous to the active energy and another to the reactive

18.3.8 Calender Clock

The Meter shall have a Calendar clock to provide time and date information and be equipped with built in battery backup. Battery life shall be not less than 10 years.

18.3.9 Memory:

The Meter shall have facilities to store a minimum of twelve months of billing history data, Load Profile data for at least forty five (45) days (Load profile data shall contain parameters, active power, reactive power and apparent power in both directions, power factor, voltage of each phase and current of each phase at 15 minute interval), Event Log Data (minimum 100 records). Each event log or tamper log shall have the date and time of occurrence and restoration. However, these log channels and parameters shall be user configurable. Sampling period for load profile shall be 30s or less. There shall be a facility in the Meter to select average/ maximum/ minimum of the values to be recorded in Load profile.
It shall have sufficient channels in Load Profile to capture power quality data such as THD in current and voltage
For the display, the Meter shall have non-volatile memory type electronic display. The non-volatile memory shall have a minimum retention time of twelve months. The principle unit for the measured value shall be kilowatt-hour (kWh) and kVA and kW.

18.3.10 Metering Programming Facility:

It shall be possible to fully program display settings, time of day tariff settings, CT/VT ratios, load profile parameters, automatic billing/resetting date and time, historical registers and other programmable parameters, reset the maximum demand, and download data both locally and remotely through suitable software running on PC without any assistance of the manufacturer.

18.3.11 Local Remote Communication:

The Meter shall be accessible from the communication software installed and running on Windows based PC supplied by EFL.
The manufacturer shall disclose and provide all necessary protocol information or API (Application Programming Interface) to EFL at any time throughout the guaranteed life span of the Meter, so that independently developed HES (Head End System) and MDMS (Meter Database Management System) can freely communicate with the Meter and manage its data as required.

18.3.12 Communication Port:

The Meter shall have following communication ports for local/remote reading:

- Optical port (Locally programming and downloading data)
- RS232 port (for remote communication using GSM/GPRS Modem)
- TCP/IP Ethernet (should be configurable on DLMS TCP/MODBUS TCP)

18.3.13 Local/Remote Accessibility

The shall be available to carry out following tasks for each of the meter locally/remotely.

- To program each meter
- To take the relevant meter readings for each meter separately
- To reset the maximum demand value of each meter.
- To get error messages when the meter is faulty, tampering of meter etc and the date and time of occurrence of such event.
- To download stored data from meter (Present values, Historical values, Load Profiles)

18.3.14 Communication System:

A user-friendly windows based Graphical User Interface (GUI) basic software with free license to install in any number of PCs shall be supplied on a CD with the meters in order to programme the meters (locally and remotely) and to download the data from the remote data communication facilitated meters. The software shall have the facility to communicate via a communication modem connected to the PC. Relevant manuals in English language shall be provided.
The downloaded data shall be stored in a suitable fool proof database. This data shall be able to be extracted as a delimited MS Excel format.
Software shall be valid or provided with necessary keys and upgrades for at least the full life span of the Meter. The manufacturer/ supplier shall provide necessary support throughout this period. The software should facilitate remote data downloading individually from each meter as well as batch wise data downloading of particular set of meters through automated function.

18.4 Mechanical Requirement:

The Meter shall be designed and constructed in such a way as to avoid introducing any danger in normal use and under normal working conditions, so as to ensure especially;

- Personal safety against electric shock
- Personal safety against effects of excessive temperature
- Safety against spread of fire
- Protection against penetration of solid objects, dust and water.

All parts which are subject to corrosion shall be suitably protected and any protective coating shall not be liable to damage by normal handling

18.4.1 Case Window

The Meter shall have an insulated case which shall be sealed in such a way that the internal parts of the meter are not accessible to unauthorized persons such that double insulation for the meter is ensured.

18.4.2 Terminal Block:

The terminal block shall be made of insulating material and it shall be capable of passing the test stipulated in ISO 75-2:2013 for a temperature of 1350C and a pressure of 1.8 MPa.
Each terminal shall have two screws for effectively clamping two numbers 2.5mm2 copper cables and the bore of the terminals shall be adequate enough to accommodate two numbers 2.5mm2 copper cables. It shall be made of tin/nickle plated brass/copper.

18.4.3 Terminal Cover:

The wiring terminals shall be protected by a sealable terminal cover, and the terminal cover shall be made of an insulating material.
The terminal covers shall be of extended type with easily breakable knockouts. Provision shall be made to seal the meter cover and terminal cover separately.

18.4.4 Resistance to Heat & Fire

The terminal block, the terminal cover and the meter case shall not ignite by thermic overload of live parts in contact with them and they shall meet the tests stipulated in Clause 5.8 of IEC 62052-11.

18.4.5 Protection against Penetration of Water & Dust

The Metering equipment shall be suitable for indoor use and conform to the degree of protection of IP51 as per IEC 60529.

18.4.6 Display of Measured value:

The Meter shall be provided with a LED Display under a viewing panel conforming to the degree of protection of IP 65 and the dimensions of figures shall not be less than 4 mm (Height) and 4mm (Width). Minimum number of digits shall be 10 including the decimal point and shall be capable of showing three decimal points in a particular reading.

18.4.7 Output Devices

The Meter shall have a test output device (outlet port) accessible from the front and capable of being tested with the help of the universal reference standard meter.

18.5 CLIMATE CONDITION

18.5.1 Temperature Range

The operating Temperature range of the Meters shall conform to the table 5 of IEC 62052-11 for indoor meters.

18.5.2 Relative Humidity

The meters shall be suitable for indoor operation in a humid tropical climatic condition with the maximum relative humidity of 90%.

18.5.3 Influence of Heating

The temperature rise at any point of the external surface of the meter shall not exceed 25K with the ambient temperature at 400C. Under normal operating condition the electrical circuits and insulation shall not reach a temperature which might affect the operation of the meter.

18.6 Electromagnetic Compatibility

a) Immunity to Electromagnetic Disturbance
The Meters shall be designed in such a way that conducted or radiated electromagnetic disturbance as well as electrostatic discharge do not damage or influence the meter
b) Radio Interference Suppression
The Meters shall not generate, conduct or radiate noise which could interfere with other equipment.

18.7 Accuracy requirement

a) Starting and Running with No Load
The Meter shall be fully functional within 5 seconds after the voltage is applied to the meter terminals.
When the voltage is applied with no current flowing in the current circuit the test output of the meter shall not produce more than one pulse. The meter shall start and continue to register at 0.001 of basic current.
b) Meter constant
Sufficient pulse rate (meter constant) shall be generated at low load condition (1/10 of CT ratio). The relation between the test output and the indication in the display shall comply with the marking on the name plate.

18.8 MARKING OF METER

a) Every meter shall be indelibly marked with a diagram of connections and this diagram shall also show the sequence for which the meter is intended, preferably inside the meter terminal cover.
b) The Name Plate of Meters shall bear all the information stipulated in clause 5.12 of IEC 62052.

c) The words “Property of the Energy Fiji Limited (EFL) with a mark “Warranty 5Y “shall be engraved on the nameplate.
d) Serial number (which will be indicated at the time of placing an order) shall also be engraved on the nameplate

18.9 QUALITY ASSURANCE

The manufacturer shall possess ISO 9001 Quality Assurance Certification for the design, manufacture and testing of Programmable Static Poly phase Energy Meters. In the event the meters are manufactured in a plant under the licensed of the manufacturer, the manufacturing plant shall possess ISO 9001 Quality Assurance Certificate for manufacturing and testing of Three Phase Energy Meters. The Bidder shall furnish a copy of the ISO Certificate certified as true copy of the original from the manufacturers, along with the offer.
Each Meter to be tested and calibrated at a meter testing laboratory having ISO/IEC: 17025:2015 and properly sealed with security synthetic seal with identification numbers. Test report shall be dispatched to the purchaser before inspection The proof documents with regard to the accreditation for the above facility in accordance with ISO/IEC: 17025:2005 shall be submitted along with the bid.

18.9.1 Testing Installation & commissioning

Type Test
The following Type Test Certificates conforming to IEC 62052-11 shall be furnished during detail Engineering.

i. Test of insulating properties
- Impulse test voltage
- A.C. Voltage Test

ii. Test of Accuracy requirements
- Test of meter constant
- Test of starting condition
- Test of no-load condition
- Test of influence quantities

iii. Test of electrical requirements
- Test of power consumption
- Test of influence of supply voltage
- Test of influence of short-time current
- Test of influence of self-heating
- Test of influence of heating
- Test of immunity to earth fault

iv. Test of electromagnetic compatibility
- Radio interference suppression
- Fast transient burst test
- Damped oscillatory waves immunity test
- Test of immunity to electromagnetic RF fields
- Test of immunity to conducted disturbances, induced by radio- frequency fields
- Test of immunity to electrostatic discharges.
- Surge immunity test

v. Tests of the effect of the climatic environments
- Dry heat test
- Cold test
- Damp heat cyclic test
- Solar radiation test

vi. Mechanical Tests
- Vibration Test
- Shock test
- Spring Hammer Test
- Tests of protection against penetration of dust and water
- Test of resistance to heat and fire

The Type Test Certificates shall clearly indicate the following;
- Name, Address and Country of the Testing Authority
- Date of Testing
- Name of Equipment Type Tested
- Number of pages of the Type Test certificates
- Manufacturing identity /Catalogue Reference Number
- Basic Prameters
- The Standard to which the equipment Type tested.
- Comments and Observations of the Testing Authority

The Type Test shall be performed at a reference voltage of 110V/400V at a reference frequency of 50Hz.
Type Test Certificates shall be from an accredited independent testing laboratory acceptable to the EFL complying to ISO/IEC 17025. Proof of accreditation by a national/international authority shall be forwarded with the offer. Test reports shall be complete including all the pages as issued by the testing authority. Type test reports shall be in English language. Parts of test reports shall not be acceptable

Acceptance Test

Following tests shall be carried out conforming to IEC 62052 – 11, IEC 62053-22, IEC 62053-23 and IEC 62058-31 under the witness of;

- An independent testing authority acceptable to EFL

For energy metering, measuring signal shall be taken from dedicated class 0.2 cores/windings of CTs and VTs installed in each Transformer Incomer, Generator feeder and Distribution feeders.

18.9.2 Meter Panel

All panels shall be constructed or braced rolled steel section, with recessed panels and substantial mounting sheets for power and control cable work. All steelwork shall be constructed of steel sheets.

with a minimum thickness of 2mm. The minimum width, depth and height of all cubicles shall be 800 mm, 800mm and 2200 mm respectively.

The interior of each cubicle shall be finished with a mat light coloured surface and an interior lamp suitable for local LVAC supply and controlled by a door-operating switch and fitted at the top of each cubicle. Anti-condensation heaters shall also be fitted in each cubicle and each cubicle shall be well ventilated top and bottom through vermin proof louvers fitted with brass gauze screens. Each protection cubicle shall also be equipped with a built in AC supply socket outlet of single phase. Three wire rated 13 A at 230 V, 50 Hz.

The cubicle shall be of the self-standing, floor-mounted type and shall be provided with ways and means for floor fixing and anchoring devices. They shall be supplied completely with their fixing and lifting racks and eyebolts. Equipment and terminals shall be readily accessible and shall require a minimum of disturbance of associated adjacent equipment for access. The arrangement of panel wiring and multicore cable terminal boards shall be in accordance with the relevant clauses of Chapter 3 of this Specification.

Enclosures shall be provided for bottom entry of power and multi core cables via gland plates. Removable gland plates shall be located within the cubicles so as to provide adequate working clearance for terminating the cables.

Enclosures shall be provided for bottom entry of power and multi core cables via gland plates. Removable gland plates shall be located within the cubicles so as to provide adequate working clearance for terminating the cables.

Where any sensitive equipment are mounted on hinged front panels, these shall be designed to minimize shock and wiring shall be so arranged as to impose no strain on terminations. No equipment whatsoever shall be mounted on rear access doors.

All sections of a composite cubicle shall be suitably labelled in accordance with the specification and labels at the rear shall also readily identify each section or panel with the access doors either opens or close.
Each panel shall be of the swing rack type including 19" swing frame and a front cover door equipped with a glass window and each control panel shall be of the enclosed type.
The indoor meter panel shall be of at least IP 55 protection class. Each door shall be fitted with suitable earth straps of at least 16 mm2 highly flexible stranded copper wire with an insulation in green-yellow colour.
Doors are to be arranged so that every individual door or frame can be opened without moving doors of adjacent cubicles. Doors shall be of 2mm thick sheet steel, equipped with 120° concealed hinges, with foamed-in seal and shall be provided with a stable, bolted, rectangular tube frame, with pre- punched holes at 25 mm pitch for fixing channels, covers, cable harnesses, wiring plan pockets and etc. The door stopper at the end of the throw shall be provided. Doors shall be handled by smooth action locking bars with rollers and security lock system, prepared for insert lengths of 40 or 50 mm. The insert shall be provided in accordance with the master key system of Employer, for which details shall be forwarded to the contractor on request.
The contractor shall perform a calculation for the heat dissipation for enclosures with the maximum installed heat-losses and shall propose a suitable temperature control method. However the method has to be approved by the Engineer.
Panels and cabinets are to be installed in totally air-conditioned control rooms. Cubicles provided as extensions or for erection in the same room with existing cubicles shall be of similar appearance. All enclosures and accessories such as swing frames shall be corrosion protected by electrophoresis- dip-coat primers and final coats by an approved procedure as to suit the surrounding conditions at site.

The arrangement and mounting of meters and all other devices shall be to the approval of the EFL. The exterior and interior finish and colour of all cubicles shall be to the approval of the Engineer Engineer

18.9.3 Terminal Block

All In selecting cable and wire sizes, due regard shall be paid to the appropriate de-rating factors in relation to the climate conditions at site. All cables and wires shall continuously carry their rated currents under the worst temperature conditions and shall also withstand maximum fault currents without damage or deterioration.

All secondary copper wiring within panels, racks, boards, etc. shall be in accordance with the pertaining IEC, it shall be carried out for the fully rated distribution voltage (2

kV AC/ 1 min. test voltage) and shall consists of copper wires. The bare ands of stranded wires shall be provided with squeezed sleeves.
The minimum Cross-section of each copper wire shall be at least as specified in the chapter 3 of this specification. Wiring shall be neatly run in PVC rigid plastic wire-ways, clear of any metal panels and filled not more than 70% or bundles with no bunch containing more than 12 wires. All power and control cables used for less than 60 V DC shall be laid and terminated separately. Where power and control cables cannot be laid separately, suitable metallic barriers shall be provided.

Both ends of every wire core and all secondary panel wiring above 60 V (at the screwed terminal side for external connection as well as at the screwed device sides in the panel) shall be fitted with numbered slip-on ferrules of moisture and oil-resisting insulation material having a glossy finish, and with their identification numbers clearly engraved, each being the same as for the relevant terminal.

Ferrules of white colour with black letters, shall be fitted in such a way that they cannot become detached when the wire is removed from the terminal. (i.e. end crimps shall be provided).
All secondary wiring to be performed at the site shall enter the terminal block at one side only. The panel wiring shall terminate in one or more terminal blocks accommodated at the side or bottom of each panel. Internal wiring between meters shall be permitted within the same cubicle only.

Cables with spiral wrap designed shield shall be used for the current transformer circuits and voltage transformer circuits. The shield shall be grounded at both ends of the cable. Generally, for wiring, the cable tails shall be so bound that each wire may be tracked back to its associated cable without difficulty. Cores in pairs or groups shall be terminated together.

All incoming control cables shall contain minimum 20% spare cores and be connected to terminal blocks, with 20% spare terminals of each type. Any further spare cores shall be numbered included in the list of cable table and shall be sealed in further spare terminals.

18.9.4 Meter Installation

Contractor shall perform visual inspection to ensure that there is no damage resulting from shipment. Contractor shall install meters in accordance with the drawings and manufacturer's instructions. Any damaged paintwork shall be touched up.

Meters should be programmed by the contractor for the settings specified in this specification and for any other variations requested at the time of installation.
Terminals and connecting cables from voltage transformers, and current transformers up to and including the meter (including any and all terminations between voltage/current transformers and the meter) shall be made inaccessible by a sealed cover, complete with an approved seal. Furthermore, meters shall be sealed with an approved seal.
Energy meters shall be supplied from dedicated VT windings and CT cores. No other loads shall be connected to these windings/cores.
Energy meters shall be installed on a dedicated panel in the existing station relay room.
Contractor should perform an accuracy measurement test and check the CT and VT ratios using secondary injection methodology or any other means to the satisfaction of the Engineer.
Technical literature in English language on the installation, calibration and maintenance shall be supplied with each set of meters, and they shall be descriptive and self-explanatory, complete with necessary connection diagrams and drawings.
The Contractor shall prove to the satisfaction of the Engineer and the Owner, that the metering system and remote access to the meter system is functional, in all regards.

18.10 ADDITIONAL INFORMATION TO BE PROVIDED

- A comprehensive catalogue describing the equipment and indicating the type and model number.
- Literature describing the operational feature of the equipment.

- Constructional features, materials used for components and relevant technical literature.
- Complete dimensional drawings.

- Quality assurance certifications conforms to ISO 9001 and ISO/IEC 17025 accreditatio
- Type test and routine test certificates in accordance with clause 5 of this specification.
- (The type test shall be performed at the applicable reference voltage and reference frequency of 50 Hz.)
- Certificate of compliance to DLMS issued by DLMS Association.
- Non-Compliances Schedule if there are any deviations to the specification
- Manufacturing Experience, List of utilities to whom the manufacture had supplied relevant items and Certificate for service life.

18.11 OTHER Technical Requirements

Contractor shall supply energy meters along with metering station, MRI as per the technical specification given below:

a) The active and reactive energy shall be directly computed in CT & VT primary ratings.
b) The reactive energy shall be recorded for each metering interval in four different registers as MVARh (lag) when active export, MVARh (Lag) when active import, MVARh (lead) when active export, MVARh (Lead) when active import.
c) Two separate registers shall be provided to record MVARH when system voltage is >103% and when system voltage is < 97%.
d) Shall compute the net MWh and MVARh during each successive 15-minute block metering interval along with a plus/minus sign, instantaneous MWh, instantaneous MVARh, average frequency of each 15 minutes, net active energy at midnight, , net reactive energy for voltage low and high conditions at each midnight.
e) Each energy meter shall have a display unit. It shall display the net MWh and MVARh with a plus/minus sign and average frequency during the previous metering interval; peak MWh demand since the last demand reset; accumulated total (instantaneous) MWh and MVARh with a plus/minus sign, date and time; and instantaneous current and voltage on each phases.
f) All the registers shall be stored in a non-volatile memory. Meter registers for each metering interval, as well as accumulated totals, shall be downloadable. All the net active/reactive energy values displayed or stored shall be with a plus /minus sign for export/import.
g) At least the following data shall be stored before being over-written for the following parameters.

	Parameters	Details	Min No of days
1.	Net MWH	15 min block	**40days in meter**
2.	Aver Freq	15 min block	**40days in meter**
3.	Net MVARH for V > 103%	15min block	**40days in meter**
4.	Net MVARH for V < 97%	15min block	**40days in meter**
5.	Cumulative Net MWH at every midnight		**10 days in meter/ 40 days in PC**

6.	Cumulative Net MVARH for V> 103% at every midnight		**10 days in Meter/ 40 days in PC**
7.	Cumulative Net MVARH for V < 97% At every midnight		**10 days in Meter/ 40 days in PC**
8.	Date and time blocks of VT failure on any phase.		

h) Shall have a built in clock and calendar with an accuracy of less than 15 seconds per month drift without assistance of external time synchronizing pulse.

i) Date/time shall be displayed on demand. The clock shall be synchronized by GPS time synchronization equipment being supplied by the contractor.

j) The voltage monitoring of shall be inbuilt feature provided to signal failures to the Substation Automation System, The meter shall be suitable to operate with power drawn from the VT supplies. The burden of the meters shall be less than 2 VA.

k) The power supply to the meter shall be healthy even with a single-phase VT supply. An automatic backup, in the event of non-availability of voltage in all the phases, shall be provided by a built in long life battery and shall not need replacement for at least 10 years with a continuous VT interruption of at least 2 years. Even under absence of VT input, energy meter display shall be available and it shall be possible to download data from the energy meter. Incase data downloading is not possible in absence of VT supply, meter with provision of 220V DC auxiliary power shall be provided. Date and time of VT interruption and restoration shall be automatically stored in a non-volatile memory.

l) Shall have an optical port on the front of the meter for data collection from either a hand held meter reading instrument (MRI) having a display for energy readings or from a notebook computer with suitable software. The contractor shall supply the MRI and/or notebook complete with all optical interface unit required.

m) The meter shall have means to test MWh and MVARh accuracy and calibration at site in-situ and test terminal blocks shall be provided for the same.

n) Each meter shall have a unique identification code provided by the Owner and shall be permanently marked on the front of the meter and stored in the non-volatile memory of the meter.

18.12 Additional Requirements of PQ meters:

Suitable PQ meters (0.2 accuracy class) shall be provided at necessary locations (as per scope of work) for measurement of required electrical parameters such as active power, reactive power, power factor, voltage, current, frequency, power quality paraments, etc. PQ meter shall have TCP/IP port for SCADA and PPC communication. Selected PQ meters shall be able to measure grid frequency with minimum two digit after decimal point. CT and PT/CVT core used for PQ meters shall have accuracy class of 0.2S and 0.2 respectively. These PQ meters should have auto report generation facility of daily reports of Harmonics/Flicker and DC currents as per IEEE519/IEC61000 accessible from OWS of PPC system so that it can be submitted in relevant REMC/RLDC. Necessary software for visualization of online parameters and setting in PQM in OWS(PPC) must be supplied along with PQM.

Standards: -

- IEEE Standards: Compliance with latest IEEE 519:2022, IEEE 1547.1:2020, IEEE 2800: 2022
- Grid Codes: Adhering to local grid interconnection standards which dictate power quality requirements..
- International Standards: Following IEC standards for testing and performance of electrical components in solar power plants- IEC 61000-4-30:2015 Class A Power Quality meters.

Salient Technical parameters of PQM: -

- Sample rate choice of 512 Samples/cycle or 1024 Samples/cycle
- Storage memory options ensuring more than 90 days storage in the device as specified by EFL
- Historical Logs –8 no.s, providing robust computation capability.
- Voltage Sag/swell, Flicker, Transient logs
- Cyber Security.
- Post event/fault capability to capture 10 sec as specified by EFL and also exceeding the same if the need arises.
- Able to capture LVRT/HVRT fault waveform signature as per EFL requirement.

19. Battery Energy Storage System (BESS)

- BESS along with PCS, BMS, EMS and all evacuation infrastructure complete to meet the 3 % ramp rate requirement of solar power plant at Point of Injection.
- Minimum Size of the BESS should be 6 MW / 12 MWh measured at 33kV Pooling Switchgear. Bidder has to consider all losses and APC consumption for during BESS capacity designing.
- Bidder may suggest higher rating BESS.
- BESS should be containerized standard solution available in the market.
- Designed Life of BESS system shall be minimum 12 years or 6000 Cycles of Operation which ever come earlier.
- Note: A complete cycle of the BESS is defined as the cumulative energy throughput equal to its full rated capacity. The energy management system (EMS) must be able to track and log the total number of cycles based on this energy-based definition.
- BESS should capable to achieve the 3 % ramp rate of project during resource side variation like cloud movement etc.
- BESS along with BMS & PCS shall be capable to respond to GRID frequency fluctuation as required for GRID dafety.
- Bidder has to demonstrate the ramp rate capability of the plant yearly.
- BESS should be capable to supply full capacity of power at 33 kV BESS HT pooling switchgear within 500milli Seconds of the command from PPC or EMS.
- PCS of the BESS should have all the safety features and also have black start feature in case of supply power during Grid blackout. PCS shall have rating to supply the inrush current of transformer during black start requirement.
- During Non-solar hours Auxiliary power requirement of the solar and BESS project will be supplied by BESS.
- Container should have corrosion category of C-5 M.
- Container Should be designed as per NFPA guidelines for fire protection.
- Container should have smoke and fire detection system along with warning mechanism.

19.1 Specification of BESS

Sl.no	Description	Specification
1	Minimum Capacity	6 MW /12 MWh
2	Charge Rate	0.5C
3	Discharge Rate	0.5C

4	RTE Excluding APC	85 %
5.	Interconnection Voltage	33 kV
6.	System Frequency	50 Hz
7.	Harmonics	As per IEEE 519 & IEEE 1547
8.	Communication Ports	To be Integrated with Solar SCADA system/ PPC
9	Operating Temp Range	10 degree C to 50 degree C
10.	Depth of Discharge	≥ 90%
11.	Capacity Degradation per Year	≤ 2.5 %
12	Battery Cell Chemistry	any suitable chemistry
13	EOL of Battery Cell	≤ 65 % of SoH

19.2 PCS of the BESS should Meet the following requirement:

The Power Conversion System (PCS) shall be bi-directional Inverter and shall act as an interface between the DC battery system & the AC grid. PCS shall be designed to charge & discharge the BESS battery in coordination with energy management system and battery management system. The PCS shall consist of fast acting solid state electronic switch along with all associated control & protection, filtering, measuring instruments and data logging devices. The PCS shall be bi-directional inverter with four quadrant operation. The PCS output shall always follow the grid voltage & frequency by sensing the grid voltage and phase and the PCS shall always remain synchronized with the grid. The PCS shall use only self- commutated device which shall be adequately rated. PCS shall have GRID forming & black start capabilities and will be able to supply the in rush current of transformers & other devices during black start of the plant. All PCS shall have the same feature.

19.3 CODES AND STANDARDS

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

Standard	Description
IEC 61683 Ed.1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency requirements
IEC 61000-6-2 Ed.2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments

IEC 61000-6-4 Ed.2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEEE 519-2022	Recommended practices and requirements for harmonic control in electrical power systems
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
IEC 62116 Ed.2	Testing procedure - Islanding prevention measures for power conditioners used in grid-connected photovoltaic (PV) power generation systems
IEC 62477-1	Safety Requirements for Power Electronic Converter Systems and Equipment - Part 1: General
IEC 62477-2	Safety Requirements for Power Electronic Converter Systems and Equipment - Part 2: Power electronic converters from 1000 V AC or 1500 V DC up to 36 kV AC or 54 kV DC
IEEE 1547 / IEC 61727 / BDEW (as applicable)	Standard for interfacing solar PV plant with utility grid
IEC 60529	Ingress protection test
IEC 62619	Safety tests and requirements for secondary (rechargeable) lithium-ion cells and batteries used in industrial applications
IEC 62620	Performance requirements and test methods for secondary lithium-ion cells and batteries used in industrial settings
IEC 62485-5	Safety requirements for the installation, use, and maintenance of stationary lithium-ion batteries and battery installations with a maximum voltage of 1500 V DC
IEC 63056	Safety requirements for secondary lithium cells and batteries specifically intended for use in Electrical Energy Storage (EES) systems
IEC 62281	Safety guidelines for the transport of both primary (non-rechargeable) and secondary (rechargeable) lithium cells

	and batteries across all modes of transport (air, sea, road, rail)
IEC 62933	Standards for Electrical Energy Storage (EES) systems covering terminology, performance testing, safety, and environmental issues
IEC 61427-2	Requirements and test methods for secondary batteries used in on-grid renewable energy storage applications
IEC 61882	Hazard and Operability Studies (HAZOP)
UN 38.3	Testing required for the safe transport of lithium metal and lithium-ion batteries

19.4 GENERAL REQUIREMENTS

PCS shall meet the following technical parameter

Sr. No.	Parameter	Requirement
1	Nominal output voltage frequency	50 Hz
2	Continuous operating frequency range	47.5 Hz to 52.5 Hz
3	AC Voltage Range	±10% of rated AC voltage
4	Euro efficiency	Minimum 97% (as per IEC 61683)
5	Surge Protection Device (SPD)	Type-I & Type-II on DC side; Type-II on AC side
6	Operating power factor range	0.8 leading to 0.8 lagging (minimum)
7	SVG / Four Quadrant Operation	Required
8	Current harmonics	IEEE 519
9	Current THD value	< 3% at nominal power
10	DC Injection	< 0.5% of rated current
11	Operating ambient temperature	0°C to 60°C
12	Humidity	95% non-condensing
13	Maximum noise level	75 dBA (for indoor application)
14	Flicker	As per international standard
15	Remote start and stop facility from SCADA/EMS/PPC	Required

16	Active power limit control, reactive power control, and power factor control features	Required; configurable through PPC and/or EMS/SCADA
17	PCS designed DC fault current level	Maximum short-circuit current of the connected battery system and corresponding fault duration
18	PCS designed AC fault current level	Maximum short-circuit current on the LV side of the inverter duty transformer, with a fault duration of one second
19	• AC & DC overcurrent protection. • Synchronization loss protection. • Over temperature protection. • DC & AC under and over voltage protection. • Under & over frequency protection. • Cooling system failure protection • Battery array ground fault monitoring & detection (if applicable) • Battery system insulation monitoring (if applicable) • LVRT protection • Anti-islanding protection • Grid monitoring • (X)GRID forming & Black start feature	Required

- The PCS shall comply with the EFL (standards for connectivity to the grid) regulation with all latest amendments.
- The PCS shall be capable of supplying reactive power as per grid requirement. PCS shall have Static Var Generation (SVG) function

- The PCS, in conjunction with the control system, shall be capable of completely automatic, unattended operation, including self-protection, synchronizing and paralleling with the utility, and disconnect.
- The PCS shall have protection against any sustained fault in the feeder line and against lightning discharge in the feeder line.
- The Contractor shall ensure by carrying out all necessary studies that the PCS will not excite any resonant conditions in the system that may result in the islanded operation of BESS plant and loss of generation. In case there is excitation of any resonant condition in the system during BESS plant operation that may result in the islanding/tripping of the BESS plant and affect the power transfer, it shall be the responsibility of contractor to rectify the design and carryout required modification in the equipment of his supply.
- The PCS must be self-managing and stable in operation.
- In case of grid failure, the PCU shall be re-synchronized with grid after revival of power supply. Bidder to furnish the time taken by PCU to be re-synchronized after restoration of grid supply during detailed engineering. However, if required by Grid, PCU has the capability for GRID formation using black start feature.
- The PCS shall include appropriate self-protective and self-diagnostic feature to protect itself and the Battery system from damage in the event of PCS component failure or from parameters beyond the PCS's safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCS front panel to cause the PCS to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCS protective devices.
- PCS shall have necessary limiters in build in the controller so as to ensure safe operation of the PCU within the designed operational parameters.
- PCS shall have thermal overloading protection to prevent failure of switching devices and other components of Inverter. PCS controller shall automatically regulate/limit the power output to reduce the PCS cabinet and switching devices temperature. Bidder to submit the PCS power vs ambient temperature curve during details engineering stage. PCS shall be able to provide inverter inside cabinet and switching devices temperature (in soft analog value) to SCADA system for remote monitoring, storing and report generation purpose.
- PCS shall have AC and DC side monitoring capability and reporting to SCADA/EMS system (measured analog and digital value measured within PCS).Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.
- All-important alarm and trip signals shall be configured in the PCS and their corresponding Modbus address shall be provided for SCADA/EMS

configuration. Signal shall necessarily be included such as LVRT in action and trip operated, HVRT trip, islanding protection operated, over current operated, Inverter cabinet temperature high alarm and all other important signals. Details shall be finalized during details engineering stage.

- The PCS shall be earthed as per manufacturer recommendation. During detail engineering the Bidder needs to submit the details earthing arrangement of PCS and system earth pit requirement during detail engineering stage. The detail specification for panel earthing for safety has been mentioned elsewhere in this specification.
- The PCS shall be capable of starting and operating as black start i.e., without the presence of the utility voltage. Exercise of the black start capability shall be manual and interlocked and shall under no circumstance result in an accidental energizing of the Host Utility's bus. PCS black start shall be possible from EMS without any setting modification at PCS panel locally.
- In case auxiliary supply of PCS is met internally, then it should have sufficient power backup to meet the LVRT requirement.
- Bidder to submit third-party verified OND files of the PCS during detail engineering.

19.5 Type Testing

During detailed engineering, the contractor shall submit all the type test reports including temperature rise test and surge withstand test carried out within last ten years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

19.6 Battery Subsystem Design Requirements:

Electrochemical Cells

Only cells that are commercially available or for which suitable (not necessarily identical) replacement cells can be supplied on short notice will be allowed. For both premature cell failures and end-of-battery-life replacement, the Contractor shall guarantee cell availability and the length of down time (hours or days) required to replace cells. The cells may be supplied as separate, individual units or as group of cells combined into modules. The cells shall meet the seismic requirements for the planned location of the BESS. Cell and module design shall accommodate the anticipated vibrations and shocks associated with the transportation of the BESS and shall resist deterioration due to vibrations resulting from the same. Associated hardware and paraphernalia should also be able to withstand the rigors of transportation. The transport plan shall be shared with the Employer and approved prior to dispatch.

Labelling of cells or unit batteries shall include manufacturer's name, cell type, nameplate rating, and year of manufacture etc (to be decided during detailed engineering), in fully legible characters. All cells shall be traceable to the point of origin for purpose of addressing safety issues.

Refurbished or resued battery cells are not allowed in the battery pack. Battery pack shall be assembled using only new battery cells.

Electrochemical Storage System

The storage system may consist of one or more-unit batteries. If the storage system consists of more than one unit battery, these may be electrically interconnected in any desirable series and parallel configuration to achieve the overall system storage and power rating requirements. The DC voltage of battery system shall be selected by the Bidder to suit the PCS and battery efficient and safe operational requirement.

Each electrically series-connected string of unit batteries shall include a means of disconnecting the string from the rest of the system and of providing over-current protection (during a fault). This protection shall be coordinated with the PCS capabilities and battery string protection and shall take into account switching or other transients and the inductance/resistance (L/R) ratio at the relevant areas of the dc system. The means of disconnect shall provide for a physical interruption of the string electrical circuit, which shall be visible to anyone servicing the individual unit batteries in the string.

If the disconnect means consists of removal of a unit battery, the storage system shall be designed to allow maintenance personnel to determine that there is no current

flowing in the string and provisions to ensure that the PCS is off before the unit battery is removed. Procedures for maintenance and/or field replacement of unit batteries shall neither require nor recommend removal of the unit battery without first ensuring that no current is flowing in the string circuit.

Over-current protection, whether on the ac or dc side, in paralleled unit battery strings shall be sized and coordinated so that currents from other strings do not contribute to a fault in any unit battery string.

Where appropriate, dc wiring shall be braced for available fault currents. Protection shall include a dc breaker, fuse, or other current-limiting device on the battery bus. This protection shall be coordinated with the PCS capabilities and battery string protection. The Contractor shall produce a fault analysis and protection coordination study for the battery dc subsystem during final design. The Employer reserves the right to withhold permission to ship the BESS until the fault analysis has been satisfactorily completed.

Cells, wiring, switch gear, and all dc electrical components shall be insulated for the maximum expected voltages plus a suitable factor of safety as per standard/subject to approval during detail engineering. Cell and module terminals and interconnects shall have adequate current-carrying capacity. The polarities of cell and module terminal posts shall be embossed on the cover at the terminal.

The battery system shall include a system to detect and alarm excessive ground leakage current levels. Ground fault detection shall be enabled for the container or, if more than one electrical series string is installed in the container, for each series string. The detection/trip level shall be field adjustable. The Contractor shall have overall responsibility for the safety of the electrical design and installation of the battery, as well as all aspects of the BESS.

The battery system shall include a monitoring/alarm system and/or prescribed maintenance procedures to detect abnormal unit battery conditions and notify proper personnel of their occurrence.

Abnormal conditions shall include but not be limited to (1) weak unit batteries that could reasonably be expected to fail to provide rated capacity upon full discharge, (2) high-resistance or open-unit batteries, (3) high-resistance or open external unit battery connections, (4) unit batteries with temperatures exceeding operating thresholds, and (5) internally shorted unit batteries. Unit battery monitoring, whether automatic or manual, should be specified to alert the proper personnel in a timely

manner that an abnormal unit battery condition exists or may exist. All alarms shall be part of the control system and shall include remote display or annunciation capability.

The unit batteries shall be racked or shall be housed in stackable modules. The unit batteries or cells shall be arranged and installed to permit easy access for equipment and personnel. The moveable units shall be arranged and installed to permit easy access for equipment and personnel to carry out unit removal and replacement activities. For all systems, it shall be possible to remove and replace a prematurely failed unit battery or cell (as appropriate), when system performance specifications cannot be met. The lengths and widths of all aisles and spaces into which personnel may enter in the field for operations and/or routine or unscheduled maintenance purposes, as well as egress routes from these aisles and spaces, shall conform to applicable codes and standards. All racks and metallic conductive members of stackable modules shall be grounded to earth. Racks shall meet the seismic load and road vibration requirements and shall include means to restrain cell movement during seismic events and transport. The Contractor shall furnish analyses and/or other data that show that the rack and cell designs are designed to meet all potential seismic and transport vibration requirements.

Preferably, Provision shall be made for future Augmentation/Replacement by keeping Spare Racks for accommodating Battery Stack Modules capacity.

The design of all modules and racks shall specifically account for the anticipated vibrations and shocks associated with the transportation of the BESS.

Cell/Battery Auxiliary Systems: The cells and battery system shall be supplied with all required and/or recommended accessories. This includes inter-cell connectors & monitoring devices for cell temperature and cell voltage, if required.

19.7 BATTERY MANAGEMENT SYSTEM (BMS):

The BMS shall be designed to provide automatic, unattended operation of the battery storage system. BMS shall manage a rechargeable battery (cell or battery pack), including protecting the battery from operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it.

a) Battery storage shall discharge based on battery capacity and real-time load. The reference value shall be updated periodically depending upon the electrical parameter measurement. The charging shall be performed in constant current constant voltage (CCCV) mode. However, change of operating

mode from CC to CV during charging shall be determined on the basis of Supplier recommendations and the battery type and technology offered.

b) The battery storage shall discharge on real time basis as per functional requirement. Battery SoC shall be monitored periodically to evaluate the remaining capacity at start of discharge operation and accordingly a constant rate of discharge will be defined. Further, an additional feature shall be provided to change/edit the discharge duration and rate of discharge whenever required.

c) BMS shall monitor battery system parameters such as string voltage & current, cumulative number of cycles and throughput along with DoD. It shall automatically determine the State of Charge (SOC) and State of Health (SOH) of the battery individual cell/module.

d) It shall also monitor utility side parameters such as voltage, charge/discharge current and protection system readings/status.

e) BMS shall automatically control the charging state of each module based on monitoring of parameters and power/energy requirements. It should charge the module in float/boost mode and/or Constant Current Constant Voltage (CC-CV) mode as per requirements of battery sub system. It shall also be designed to protect the battery cells/module/string from out of tolerance and unsafe operating conditions under any eventuality and mitigate fire risk. Further, it should regulate the voltage to limit the temperature rise in the cell.

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

g) Monitoring and storing the battery's parameters and communicating the same to SCADA/EMS.

h) Alarm and fault generation and communicating the same to SCADA/EMS

i) Isolating the battery in cases of any emergency.

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

19.8 TYPE TESTING:

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

In case of module types/ BESS/equipment for which such Test facilities may not exist in Fiji at present, test certificates from reputed ILAC Member body accredited Labs abroad will be acceptable.

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

19.9 FACTORY ACCEPTANCE TEST (FAT)

FAT procedure shall be submitted by bidder for EFL approval and after approval of FAT procedure, FAT will be witnessed by EFL Engineering or authorized representative of EFL.

20. PASSIVE HARMONIC FILTER

20.1 SCOPE

This specification outlines the detailed requirements for the design, engineering, manufacture, shop testing, packing, transport, unloading, storage at the site, installation, commissioning, and maintenance of passive harmonic filters for 33 kV power systems. The scope includes:

- Supply of filter capacitor banks, reactors, and associated components
- Ensuring compliance with IEC 60871, SAE AS5553
- Design considerations for electrical, mechanical, and environmental factors
- Protection and interlocking requirements
- Performance criteria, efficiency, and reliability standards
- Detailed factory and site testing procedures
- Documentation, training, and operational guidelines
- Coordination with existing MV switchgear and grid integration

The filter banks shall be installed outdoors and connected to the 33 kV MV bus bars. via single core power cables to the concerned switchgear bus-bar, connection between Capacitor bank to reactor shall be single core power cables. The cable arrangement for those power cables shall be subject to approval by the Client.
The installation shall be designed for long-term reliability, minimal maintenance, and optimal harmonic mitigation.

20.2 APPLICABLE STANDARDS

All components of the harmonic filter shall conform to the latest versions of the following standards:

- IEC60871-1 &2 -2014 - Shunt Capacitors for AC power systems
- IEC 60076-6:2007) - Reactors for Power Capacitors
- IEC 60099-4 - Surge Arresters
- IEC 61869-1 & 2 - Current Transformers
- IEC 62271 - Isolators and Switchgear
- IEEE 519-2022 - Harmonic Control in Power Systems
- IEC 60076-6 - Power Transformers
- IEC 60871 - High Voltage Capacitors
- PXE Oil – Biodegradable/ Environment Friendly

20.3 SCOPE OF SUPPLY

The filter banks shall include, but not be limited to:

- Filter Capacitor Banks (with series/parallel connected capacitor units, internally fused configuration)
- Series Reactors (air-core, dry-type, with appropriate tuning)
- Surge Arresters (ZnO gapless type with insulating base, heavy-duty station class)
- Unbalance Current Transformers
- Damping Resistors (for High-pass or C-Type Filters)
- Post Insulators (Porcelain/Composite, creepage distance as per pollution level)
- Tinned Copper Busbar/Cables (with proper rating and short circuit withstand capacity)
- Numerical Protection and Control Panel (SCADA compatible with remote monitoring capability)
- Interlocking Mechanism (Mechanical and Electrical safety interlocks)
- MV & LV Cable Termination Compartments
- Terminal Connectors (suitable for indoor/outdoor applications)
- Remote Control Cubicle (with necessary interface provisions)
- Mounting Structure (Hot Dip Galvanized Steel suitable for seismic and wind load conditions)
- Earthing and Discharge Devices
- Warning and Safety Signage
- Fire Protection and Arc Flash Mitigation measures
- 33kV MV cable and termination from capacitor bank to reactors.
- RAL 5012 The paint thickness shall not be less than 50 microns

20.4 PROTECTION REQUIREMENTS

Each capacitor bank shall be provided with the following protections:

- Over-current Protection (due to capacitor bank faults or individual unit failure)
- Short Circuit Protection (for Busbar and capacitor units)
- Overload Protection (Thermal and electrical)
- Capacitor Element Fuse Protection
- Over-voltage & Under-voltage Protection (Numerical Relays)
- Earth Fault Protection
- Unbalance Protection (Numerical Relay with Alarm & Trip Settings)
- Harmonic Distortion Monitoring (for compliance with IEEE 519 limits)
- Temperature Monitoring & Alarm (for capacitors, reactors, and resistors)
- Interlocking Scheme to prevent unsafe operations

The Bidder/Contractor shall co-ordinate the tripping scheme with main MV switchgear systems. Over-voltage / under-voltage may be combined within a single numerical relay designed specifically for protection of capacitor banks. Relays from the approved Contract Vendor list make only shall be utilized for capacitor bank protection.

Interlocking mechanisms shall ensure safe operation by preventing:

- Closing of capacitor bank circuit breaker when access doors are open
- Closing of grounding switch when capacitor bank is energized
- Opening of capacitor bank enclosure unless proper discharge procedure is followed
- Minimum 10-minute time delay before capacitor bank can be accessed after de-energization

Portable, insulated earthing equipment shall also be provided to earth and ensure discharge of the capacitor units before handling. This portable earth to be of special design equipped with insulated stick to enable the operator for safe earthing, more over there should be leads from the capacitors to facilitate connection of the earth.

20.5 FILTER BANK DESIGN SPECIFICATIONS

1. The capacitor bank shall be structure-mounted and suitable for outdoor installation with an IP55 protection rating.
2. The filters shall consist of passive components such as resistors, reactors, and capacitors.
3. The filter bank supplier must be the manufacturer of key components, such as capacitors, and should possess design knowledge of reactors, resistors, protection relays, and circuit breakers/switches.
4. The manufacturer must demonstrate expertise in harmonic analysis, grid integration studies, and design simulations (seismic, wind loading, etc.).
5. The filter supplier must have the expertise to conduct power quality measurements in accordance with relevant standards. This includes determining the type and class of meter to be used, as well as the location, duration, and sampling time of the power quality measurement. This is essential to ensure the proper design of the harmonic filter. Incorrect input could result in the selection of the wrong tuning frequency, leading to ineffective filtering.
6. It is essential that the filter supplier has a control panel design that is compatible with both control and SCADA integration for the filter bank in the power plant's PPC.
7. Component Tolerances:
    a. Capacitor (high-pass filters): ±7.5%

b. Capacitor (band-pass filters): ±5%
c. Reactor: ±5%
d. Resistor: ±5%
e. Tolerance on Loss: The total loss shall not exceed the guaranteed loss by more than 15%.

8. Component Losses: As per the latest IS standards, there isn't a specific standard that defines loss limits for Shunt capacitors and damping resistors used in harmonic filters. Hence we rely on the IEEE Standards for more clarity.
    a. Capacitor: IEEE 18-2012 – "IEEE Standard for Shunt Power Capacitors" standard specifies that the dissipation factor (tan δ) for power capacitors should not exceed 0.2% at the rated frequency and voltage. This corresponds to a loss of 0.2 Watts/kVAR rating of the capacitor.
    b. Reactor: IEEE C57.21-2020 (IEEE Standard for Shunt Reactors) Defines design, performance, and loss limits for reactors used in harmonic filtering and power quality applications.
    c. The combines losses must be around 0.14 %

Parameter	Limit as per IEEE C57.21-2020
Copper Loss (I^2R loss)	0.2% – 1% of rated power

9. Filter Types:
    a. Tuned Filters
    b. High-pass Filters
    c. C-type Filters
    d. Double-tuned Filters
10. Quality Factor:
    a. Band-pass Filters: ~100
    b. High-pass & C-type Filters: <10
11. Minimum expected life: 20 years with periodic maintenance.

20.6 TECHNICAL SPECIFICATIONS OF MAIN COMPONENTS

Capacitors

The capacitor units shall be manufactured by adopting latest technology in dust free environment (certified for Class 10000) to ensure higher reliability and higher breakdown strength of the capacitor unit for better performance at site. The impregnate used shall be most suitable for high temperature. The impregnation shall be carried out under high vacuum for increasing di- electric strength. The capacitor units shall be hermitically sealed by controlled robotic welding process.

a. Dielectric: Polypropylene Film, Non-PCB
b. Stainless steel container (Min. 1.5 mm thickness)
c. Welded/press fit type Bushings.
d. Discharge voltage ≤ 75V in 10 minutes
e. Routine & Type tests as per IS 13925
f. Insulation Level: As per the Voltage Level

TESTS FOR CAPACITOR UNIT

Routine tests

a. Capacitance measurement.
b. Measurement of the tangent of the loss angle (tan δ) of the capacitor.
c. Voltage test between terminals.
d. AC voltage test between terminals and container.
e. Test of internal discharge device.
f. Sealing test.
g. Discharge test on internal fuses (If applicable)

Type tests

a. Thermal Stability test
b. Measurement of the Tangent of the Loss angle of the capacitor at elevated temperature.
c. AC voltage test between terminals and container
d. Lightning impulse voltage test between terminals and container
e. Short circuit discharge test
f. Disconnecting test on internal fuses

Routine tests shall have been carried out by the manufacturer on every capacitor before delivery. If the purchaser so requests, he shall be supplied with a certificate detailing the results of such tests. The test sequence above is not mandatory.
Routine Test or Type Tests must be done as per latest IEC standards certified by as IEC 17025/ IEC 60871-1 standards.

Series Reactors

a. Air-core, dry type, aluminium wound
b. Rated Voltage: 33 kV, Max System Voltage: 36 kV, Frequency: 50 Hz
c. Compliance with IEC 60289
d. Class F insulation, Max temperature rise: 90°C (Over Ambient)

TESTS FOR REACTOR UNIT

Type & Routine Tests

a. Measurement of winding resistance
b. Measurement of insulation resistance
c. Measurement of reactance
d. Dielectric tests (including separate-source voltage withstand test, induced overvoltage withstand test, and lightening impulse voltage test)
e. Temperature-rise test
f. Inductance measurement
g. Q-factor measurement
h. Measurement of harmonic current

Routine Test or Type Tests must be done as per latest IEC Standard.

Damping Resistors

a. Resistors shall be air-insulated, air-cooled through natural convection, and of dry type suitable for outdoor use.
b. Resistors for AC filter arms shall be of effectively low inductance.
c. Resistors shall be constructed with sufficient strength to withstand mechanical forces calculated in accordance with IEC 60865-1.
d. Paint Shade: RAL 5012-Epoxy Powder Paint/ with 33kV Stand Off Insulators/ Copper Bus Bars.
   - Rated Voltage: 33 kV
   - Stainless steel elements, IP23 enclosure (birds and vermin proof)
   - Max temperature rise: 375°C
   - Compliance with BS 587

Surge Arresters

1. The surge arrestors (SAs) shall conform in general to IEC 60099-4 except to the extent modified in the specification.
2. Arresters shall be of hermetically sealed units, self-supporting construction, suitable for mounting on lattice type support structures.
3. Bidder shall furnish the technical particulars of Surge arrester. The SAs shall be of heavy-duty station class and gapless Metal Oxide type without any series or shunt gaps.
4. The SAs shall be capable of discharging over voltages occurring during switching of unloaded transformers, and long lines.
5. Arrestors shall be complete with insulating base for mounting on structures. Self- contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit with necessary connection. Suitable leakage current meters should also be supplied within the same enclosure

6. The reading of millimetre and counters shall be visible through an inspection glass panel.
7. The surge arrestors shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC-60099-4

- Voltage: 33 kV, ZnO gapless type
- Discharge current: 10 kA
- Insulation Level: 70 kVrms / 170 kV
- Creepage distance: 31 mm/kV

Neutral Current Transformer

- Voltage: 33 kV, Ratio: 10/1A or 5/1A
- Burden: 15 VA, Class: 5P20
- Insulation Level: 70 kVrms / 170 kV
- Creepage distance: 31 mm/kV

Isolators

The Isolator should be Manually operated Double Break type off load Isolator with earth switch suitable for outdoor structure mounting Separate Junction Boxes for Isolator Main Switch & Earth Switch.

- Voltage: 33 kV, Double Break Off-Load
- Interlocks: Mechanical
- Creepage distance: 31 mm/kV
- Aux contacts: 4NO + 4 NC for main switch & 4NO + 4 NC for earth switch

MOUNTING RACKS

1. The mounting racks shall be hot dip galvanized steel sections. Each end of the rack shall have provision to receive incoming line connection.
2. The racks shall be complete with rack insulators, foundation bolts or any other hardware etc. for assembly into complete bank.
3. The height of the racks of capacitor banks shall be such that for making electrical connections with other equipment, proper electrical clearances are maintained.

21. WEATHER MONITORING STATION

As a part of weather monitoring station, bidder shall provide following measuring instruments with all necessary software & hardware required to integrate with SCADA so as to enable availability of data from meteorological instruments in SCADA. Each instrument shall be supplied with necessary cables, transmitters and accessories (Trackers, Mounting and base stand etc.) provided by OEM of the sensors only.

Aux. power required by instruments and data logger (If supplied) shall be from UPS only. Data logger shall have provision to receive redundant power supply.
All the instruments to be supplied shall have valid calibration certificate.
Single sensor for measuring combination of Wind Speed, Wind Direction, Relative humidity and Rainfall is also acceptable however offered sensor shall meet the specification as mentioned in following sections.
Bidders are advised to ascertain themselves, the applicable regulation related to weather data which has to be transmitted to control centers (Telemetry). Any signal/parameter/equipment though not specifically mentioned but which are required as per statutory regulation of Fiji are also included in the scope of bidder.

21.1 SOLAR RADIATION SENSORS

Contractor shall provide Solar Radiation Sensors as per specification given in following section. Contractor has the option to provide these sensors on separate base or on a single base (radiation monitoring station) with tracker, shadow ring and transmitter etc. provided by the OEM. Calibration certificate with calibration traceability to World Radiation Reference (WRR) or World Radiation Centre (WRC) shall be furnished along with solar radiation sensors. Bidder shall provide Instrument manual in hard and soft form.

21.2 Pyranometer

Bidder shall provide minimum requisite numbers of Secondary Standard Pyranometers as per IEC-61724 for measuring incident solar radiation as per following.

Technical Requirement of Pyranometer (for GHI and GII)

Sl.No	Details	Values
1.	Principle	Thermopile
2.	Spectral Response.	310 to 2800 nm
3.	Sensitivity	Min 7 micro-volt/w/m^2
4.	Time response (95%):	Max 15 s
5.	Nonlinearity:	±0.5%
6.	Temperature Response:	±2%
7.	Tilt error:	< ±0.5%.
8.	Zero offset thermal radiation:	±7 w/m^2
9.	Zero offset temperature change	±2 w/m^2
10.	Operating temperature range:	0 deg to +80 deg.

11.	Uncertainty (95% confidence Level):	Hourly- Max-3%, Daily-Max-2%
12.	Non stability:	Max ±0.8%
13.	Response Time (95% of final value)	<5 sec

Additionally, requisite secondary class pyranometer as per IEC-61724 for measurement of Diffuse Horizontal Irradiance (DHI) shall also be supplied.

Bidder shall additionally provide an Albedometer to measure the albedo for the plant.

Shadow ring/ball for measuring DHI shall require no regular adjustment for of tracker and shadow ring/ball. Pyranometer shall be shaded throughout the day and shall be exposed to diffuse solar radiation only to provide DHI value without any calculation.

All the Pyranometers have to be mounted at single location at shadow free area. The GII Pyranometer has to be at the same inclination as the angular tilt of module mounting structure. The above quantity of pyranometers shall be installed at central weather monitoring system.

Bidder shall provide 1 (One) no. battery powered portable handheld data logger supplied by the OEM of the offered Pyranometer.

Bidder also needs to provide additional pyranometer with same specification & SCADA integration for the purpose of PG test as specified in the PG test procedure chapter.

21.3 TEMPERATURE SENSORS

Ambient Air Temperature Sensor (Qty.- 1 temperature sensor each with every pyranometer being offered for the project.)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-50° C
3.	Accuracy	± 0.2 ° C
4.	Operating Temperature	0 to 50 ° C
5.	Radiation Shield	Non-aspirated Radiation Shield

21.4 Indoor Air Temperature Sensor (Qty – 1 no. at each Inverter room)

In case outdoor inverter is offered and associated equipment like PLC/RTU panel etc. is offered inside a closed room then minimum 2 such rooms shall be provided with temperature monitoring to be hooked up with SCADA.

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-70 °C
3.	Accuracy	± 0.2 °C
4.	Operating Temperature and calibration	0 to 70 °C

21.5 Module Temperature Sensor (Qty – 1 no. per 05 MWp)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-100 °C
3.	Accuracy	± 0.2 °C
4.	Operating Temperature	0 to 100 °C

Module temperature sensor shall be fixed on the back of module surface with adhesive or tape without using any mechanical fastener.

21.6 WIND SENSOR (QTY- 1 NO)

Sl.No	Details	Values
1.	Principle	Ultrasonic Sensor
2.	Velocity range	0-75 m/ sec
3.	Threshold	0.3 m/s
4.	Operating Temperature	0 to 50 deg C
5.	Accuracy	±3% RMS

21.7 Wind Direction Sensor (Qty- 1no)

Sl.No	Details	Values
1.	Principle	Potentiometric type sensor (Resistance proportional to Wind direction) /Ultrasonic Sensor
2.	Range	0-360 deg
3.	Accuracy	±2 deg
4.	Operating Temperature	0 to 50 deg C

21.8 RELATIVE HUMIDITY (%) (QTY- 1 NO)

Sl.No	Details	Values
1.	Range	0-100 %
2.	Accuracy	±3%
3.	Resolution	1%
4.	Operating Temperature	0 to 50 deg C

22. CLOUD MONITORING AND GHI FORECASTING SYSTEM

Contractor has to provide advanced, accurate cloud monitoring system including all sensors, hardware and software, capable of monitoring the movement of cloud near the solar PV plant. System shall have the ability to detect the cloud movement and predict the change in the GHI in the project for next 30 mins with GHI data every minute. System shall be based on infra-red camera technology. The offered system should have integrated irradiation, humidity, temperatures sensors along with a data acquisition & data transmission system for better data accuracy.

The system should be capable of providing cloud height, cloud segmentation and should be able to detect the cloud movement in any direction.

Actual GHI of the project for the day is to be checked and to be compared with predicted GHI and accuracy of the prediction should be more than 80%. Supplied system shall have the capability to log, store, and display the accuracy values.

Contractor has to install the camera or sensor as per site requirement.

Cloud monitoring system should be connected with SCADA & PPC in the latest communication protocol, and contractor has to ensure the seamless integration of systems being offered.

22.1 ADDITIONAL MEASUREMENT

As per regulatory requirement, following measurement for the Solar PV is also included in the scope of bidder.

- Direct Normal Irradiance (DNI) with provision of tracking Sun.
- Sunrise and Sunset time.
- Rainfall (mm).
- Air density.

Instrument and accuracy for the above-mentioned measurement shall comply with applicable regulation with latest amendments. The additional equipment as per the IEC-61724 shall have to be supplied for the project. Other important data as required by EFL shall also have to be provided with the offered system.

22.2 CALIBRATION

All the measuring instruments to be supplied shall have valid and traceable calibration certificate. Each Pyranometer shall be recalibrated at an interval not more than two years and all other instruments shall be recalibrated at an interval not more than four years.

22.3 DATA LOGGER

Weather Monitoring system shall be provided with standalone Data logger suitable for outdoor application with IP65 Protection and industrial grade hardware suitable for operating temperature up to 55 Deg. C. Data logger shall be calibrated and proven in field for at least one year in outdoor environment. Data logger shall have following minimum features:

Processor	32 bits
Time synchronization	With Built in GPS Clock or with Solar SCADA GPC Clock
Wireless communication	GSM/GPRS Modem
Data storage	SD card, Min 16GB for storage of raw and processed data locally at resolution of 1 Second for retrieval whenever required. Data to be stored shall be in unencrypted CSV or equivalent format.

Display	LCD/LED display for easy maintenance and debugging for site engineer
Scan resolution	3 sec or better.
Analog to Digital Converter (ADC)	16 Bit, Sampling -10 Hz (Min)
I/P Channel	As required with 20 % spare of each type of channel.
Additional accessories.	Inbuilt dual-SIM cellular, Sufficient ethernet and serial and USB connectivity with data sampling rate of at least 250ms.

It shall have facility for arithmetic processing (Time Integration, Simple Average, and Moving Average etc.) of incoming raw data. Data logger shall be interfaced with Solar SCADA on Modbus preferably on TCP-IP. Vendors shall submit Factory Acceptance Test (FAT) report and procedure before dispatch of material to site. Bidder must provide all the settings in the data logger in the FAT and same shall be witnessed and approved before final dispatch. The settings in the data logger and also the scaling of WMS parameters related to GHI/GTI, and other parameters related to PG test shall be witnessed by Engineer in-charge during SAT. EFL site shall be free to install their own equipment for GHI in case the Engineer In- charge feels the same appropriate. All necessary tests as prescribed for the solar plant data logger shall be applicable for additional data logger also.

Data logger shall be provided with key-locked door access and all the cables (Power and Signal) to the data logger shall be protected with heavy duty HDPE pipes.

Project file (software, settings and sample reports) shall be handed over to site on permanent storage media (SSD) in two copies after data integrity is verified by site and weather monitoring is commissioned. Any configuration changes shall be possible only with authorized User ID and password.

Datalogger shall be Cyber Security Compliant.

Surge protection for system. – Sufficient analogue, digital and Modbus RTU Input channels for various weather sensors.

23. METEOROLOGICAL STATION

23.1 Meteorological Measurements and Forecasting Software.

- A high precision meteorological station should be installed at the power plant premises to record Global Horizontal Irradiance, plane of Array Irradiance, ambient temperature, wind speed, air pressure and other relevant meteorological data to measure the performance of the Solar Park Facility.
- The bidder shall develop a suitable methodology or use appropriate software to calculate and accurately predict the actual energy generation of the Solar Park Facility.
- This proposed transfer function shall be validated within 3 months of the commissioning of the power plant. Proposed model predictability should be at least within 80% accuracy on day ahead forecast to the actual generation of the power plant.
- Generation reduction percentage with the partial availability of the above equipment shall be clearly outlined in the energy calculation methodology/software.
- The Main Meter and Check Meter shall support the validation process on the actual generated units (kWh) against the calculated energy through the methodology/software, which EFL and EFL shall mutually agree at the time of plant commissioning.
- All the details recorded in the meteorological station as well as all other parameters that are used for the energy calculation shall be able to be fed to the EFL System Control Centre in order to make appropriate decisions in Curtailing the Solar Park Facility whenever necessary.
- Sensors shall be installed at suitable height for which Mast/Structure for the sensor shall be provided by the bidder. Proper fencing shall be provided around meteorological station where the Pyranometer, Wind, Ambient Temp. Sensor, Data logger etc. are installed.

- Commencing from the Commercial Operation Date and throughout the Term of this Agreement, the bidder shall provide forecasting data as depicted in the table below.

Forecast Type	Annual	Monthly	Weekly	3-Days Ahead Rolling Schedule	6-Hours Ahead Rolling Schedule	60 Minutes Rolling Schedule

Submission Deadline	30th June	7 days prior to the beginning of each month	3 days prior to the beginning of each week	Every day before 12:00 hrs	4 times a day (before 03:00 hrs, 09:00 hrs, 15:00 hrs, 21:00 hrs)	15 minutes prior to the beginning of each hour
Forecast Resolution	Monthly (12 data points)	Weekly (4 or 5 data points)	Daily (7 data points)	15 minutes (288 data points)	15 minutes (24 data points)	5 minutes (12 data points)
Forecasted Generation (MWh)	Minimum guaranteed monthly output (12 data points)	Minimum guaranteed weekly output (4 or 5 data points)	Minimum guaranteed daily output (7 data points)	Minimum guaranteed daily output of first day (1 data point)	–	–
Forecasted Active Power (kW)	–	–	–	15 minutes (288 data points)	15 minutes (24 data points)	5 minutes (12 data points)
Maximum Mean Error in relation to the actual value (+/-)	5%	5%	5%	10% for first 96 data points of Active Power (MW), up to 40% for next 192 data points of Active Power (MW). 5% of minimum guaranteed daily energy output	10% for 24 data points of Active Power (MW)	5% for 12 data points of Active Power (MW)
Solar Irradiance, Wind Speed, Rainfall, Ambient Temp., etc.	–	–	–	15 minutes (288 data points)	15 minutes (24 data points)	5 minutes (12 data points)
Medium / Format	In a suitable electronic format prescribed by EFL SCC	In a suitable electronic format prescribed by EFL SCC	In a suitable electronic format prescribed by EFL SCC	In a suitable electronic format prescribed by EFL SCC	EFL SCC SCADA system	EFL SCC SCADA system

23.2 SOILING STATION

The Soiling Measurement System shall measure the performance loss from a PV array due to accumulation of dust, dirt, and other site-specific contaminants, collectively known as “soiling”. Soiling Stations shall use two full-sized modules. One is allowed to soil naturally, while the other is cleaned with an automatic washing system. Power and energy are monitored for both modules.

Bidder scope cover supply of complete system and its installation that includes Data logger, Automatic Module Cleaning System, cabling, software setup and interface with solar SCADA as per the technical requirement mentioned herein. Bidder shall also provide Solar PV module and its support structure.

23.3 TECHNICAL REQUIRMENT

The system shall consist of an automatic cleaning system that prevents soiling accumulation on the PV reference module (clean one), another PV module (Soiled one) which is allowed to accumulate soiling at the site-specific rate, an electronic data acquisition and analysis unit.
All components are provided in outdoor rated NEMA 4/IP 65 enclosures for long-term outdoor use. All cables are rated for outdoor use.

Following requirements are to be taken care by bidder:-

- Data logger shall be field tested and shall be in satisfactory operation for a period not less than 6 Months.
- Data logger shall be calibrated (Measurement uncertainty less than 2%) before dispatch and calibration shall be traceable to any National/International lab. Data logger shall have flash memory not less than 1GB for local storage of data.
- Bidder shall submit the write up detailing the philosophy of measurement of soiling loss in his proposal. Measurement shall be based on comparison of Isc & Power.
- Datalogger has features that includes but not limited to Moving Average calibration, Time Integration etc.
- Bidder to facilitate the interfacing of data of Soiling Station to Solar SCADA on Modbus TCP/IP for trending, storage, retrieval and display of data.

Automatic Cleaning System
The automatic cell-washing system cleans the PV reference module for accurate measurements. The system uses a suitable liquid spray to clean the reference module at user-determined intervals. The liquid tank is minimum 100 Liter. Under typical soiling conditions the liquid reservoir must be refilled periodically using the suitable liquid specified by OEM of Soiling station/PV module supplier.
Bidder shall supply 2 Nos of spare spray nozzle along with supply.
Measurements
The following measurement readouts are available via the Modbus interface:
Direct Soiling loss readout shall be available in SCADA for display and recording.
Temperature Rating
The system shall be rated for operation in ambient air temperatures from -20 °C to 60 °C.
Any alternate technology proposed by bidder shall be reviewed during detailed engineering stage for acceptance inline to the IEC-61724.

23.4 PV ANALYZER (COMPLETE KIT WITH SOFTWARE)

Bidder shall provide minimum 2 Numbers of PV Analyzer Kits of reputed make to measure the PV Module performance. Analyzer kit shall have all necessary hardware connectors and required software for data analysis. The Offered make and model must not be obsolete and shall have valid calibration certificate. It must have required software for data analysis.

SL No	Details	Values
1.	PV Voltage	0-1500 V DC
2.	PV Current	0-30 A DC
3.	Voltage Accuracy	+/- 0.25 V
4.	Current Accuracy	+/- 40 mA
5.	Operating Temperature	0-45 Deg C

24. FIRE FIGHTING AND ALARM SYSTEM

24.1 GENERAL

The SPV plant shall be equipped with suitable fire protection & firefighting systems for protection of entire equipment, switchyard & control room as per EFL requirements and other statutory requirement of FIJI.

Bidder shall comply with recommendation of Advisory Committee for incurring premium for insurance. The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection including fire protection system for BESS.

The firefighting system for the proposed power plant for fire protection shall consist of:

- Sand buckets
- Portable fire extinguishers
- Microprocessor based fire alarm panel.
- Fire Hydrant system (if Required)

24.2 Portable Fire Extinguishers and Sand Buckets

The bidder shall comply with all applicable local regulatory requirements, codes, and standards in the design of the fire-fighting system.

For reference, the minimum number of type-tested portable fire extinguishers to be provided in the specified rooms is indicated below:

Rooms	DCP Type (ABC type) (10 Kg. Capacity)	CO_2 Type 9 kg capacity	Foam Type Hand 9 kg	Hand Portable pressurized water CO_2 9 Litre	Sand Buckets
Control Room	2	2	1	1	**1**
Each Inverter Room	1	1			
ACDB Room (If applicable	1	1			
Each Transformer Yard	1	1	1		**1**
Security Room		**1**		**2**	

24.3 Microprocessor based fire alarm panel

Bidder to provide intelligent microprocessor based main fire alarm panel of modular construction complete with central processing unit, input and output modules, power supply module, supervision control and isolator modules with 10% spare provisions in each loop. Fire detection alarm system shall include but not limited to the following items:

- Fire Alarm control Panel
- Multi Sensor smoke detector
- Heat Detectors
- Hooter cum strobe
- Manual call Point
- Hooter

- Fault isolation modules
- Control Modules
- Cables from Sensors to Fire panels.
- Digital output from the fire detection system shall be integrated with SCADA
- Network Control Module
- Interfacing of Fire Alarm System with SCADA for display and storage of status and alarm in SCADA

Multi sensor type smoke detectors and heat detectors shall be provided for below false ceiling areas of control room and ACDB and/or inverter rooms. One (01) sensor shall be provided for each 20 sqm of area. All the cable trench inside the control room and inverter room shall be provided with Multi Sensor smoke detector.

Fault Isolation module shall be provided in every room and for every 15 sensors at location proposed by Bidder to be approved by employer during detail engineering.

24.4 Fire Alarm Control Panel Indication

- Alarm conditions shall be immediately displayed on the control panel and in SCADA. Alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged the LED shall remain lit. A subsequent alarm received from another zone after acknowledgement shall illuminate the alarm LED and the panel display shall show the new alarm information.
- During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged.
- If the audible alarm signals are silenced for any reason, they shall automatically resound if another zone is activated.
- All alarm signals shall be automatically “locked in” at the control panel until the operated device is returned to its normal condition and the control panel is manually reset

There shall be weatherproof Hooter cum strobe outside and strobe inside each Inverter room and control room for indication fire alarm for respective zone/area at suitable location that is visible from all direction. All the hardware, relay and accessories required for completeness of fire alarm system is in Bidder scope. Fire alarm system shall have its own battery and charger and it shall be provided power from UPS DB. Each Inverter room and control room shall also be provided with manual call point, Alarm acknowledge and reset facility for alarm for respective zone only.

Bidder shall submit document to employer for approval that will include fire alarm system configuration, layout, BoM, Datasheet and necessary test report.

Bidder shall consider 30 % design and aging margin for selection of nos. of sensors in each loop and length of each loop. Bidder shall submit the certificate from OEM indicating maximum nos. of sensors in single loop and maximum length of single loop allowed with offered panel and type of cable to be used. Each Fire Alarm Control panel shall have provision for minimum 10 (Ten) % rounded to next higher integer but not less than 2 (two) nos. spare loops for future use of employer in CMCS room. For ICR 1 spare loop may be considered and shall be acceptable.

In case bidder proposes outdoor inverter with shed arrangement, the bidder must ensure that the inverter has provision of fire sensing system. Else, the fire detection system must be provided in the Inverter shed.

Bidder shall submit Site Acceptance Test (SAT) for approval by employer. Complete fire alarm system shall be checked at site for verification of faithful performance and completeness of the system. Bidder shall carry out necessary modification and supply hardware/accessories if required free of cost at site.

25. MODULE CLEANING SYSTEM

25.1 GENERAL

The Bidder shall design, supply, install, test, and commission a water-based solar module cleaning system for the entire Solar PV Plant. The system shall be complete in all respects including source development (tube well etc.), pumping systems, water treatment, storage facilities, piping networks, valves, flow meters, nozzles, hose pipes, and all associated accessories.

The design shall ensure that the entire solar plant can be cleaned with fresh water at least twice per month, using a water consumption rate of approximately 2 liters/module (or as recommended by the module manufacturer, whichever is stricter).

The water quality used for cleaning shall conform to the module manufacturer's recommendations. The Bidder shall provide a water softening/filtration/RO system as required to meet the specified water quality.

The complete scheme, including input points, P&ID, drawings, and design basis, shall be submitted to the Owner for approval during detailed engineering.

25.2 PIPING AND DISTRIBUTION NETWORK

1. The system shall comprise a closed-loop piping network with main lines, sub-mains, and branch lines, ensuring uniform distribution of water across the plant. Where solar blocks are separated by natural obstacles (e.g., roads, drains, nallahs), a dead-end/tree configuration may be adopted. Cut-off valves shall be provided at suitable junctions to enable isolation of sections for maintenance without disturbing the entire system.
2. HDPE pipes shall conform to ISO 4427 (latest edition). The HDPE pipe shall be suitably protected against any impact load. The HDPE pipes shall be covered with higher diameter GI pipe/NP3 Hume pipe at roads crossing for protection against any heavy loads etc. at roads section. The same protection shall also be provided wherever higher loads are expected. The bidder may also propose some other protection system for HDPE pipes.
3. Tapping points for hose connections shall be provided at regular intervals. Hose pipe length shall not exceed 50 meters. Tapping ends shall be made of GI pipe with manual isolating valves. The end of each branch/tapping point shall be bent downward or horizontal to prevent ingress of foreign materials (soil, leaves, gravel, etc.).
4. The entire network shall be pressure-tested to 0.5 N/mm^2 or twice the maximum working pressure, whichever is greater. A flow meter shall be installed at the pump discharge/main header to measure water consumption. Pressure gauges shall be installed at critical points.
5. Bidder to ensure interconnection between the sub-systems of module washing system through isolating valve, so as module cleaning may be continued in case of outage of any sub-system.
6. Bidder shall ensure that the complete module washing system is integrated suitably with bore wells, check dam, motor and water pipeline coming at the periphery of the plant.

25.3 WATER SOURCE AND STORAGE

1. For water sourcing, the Contractor shall drill a minimum of two deep bore wells of not less than 250 mm diameter and a depth of not less than 100 metres by rig boring system to assess potentiality & quantity / availability of water level for deciding filter position through any type of soil, rock & boulders etc. Bore well location shall be finalized based on a hydrogeological survey and geophysical investigation using internationally recognized methods such as Vertical Electrical Sounding (VES) or equivalent techniques. The bore wells shall be constructed using uPVC casing pipes in accordance with ISO 14686 / ISO 4065 / EN 12201 standards.

2. Submersible pumps of suitable capacity shall be installed in each bore well, complete with motor protection panels including LED indicators, ammeter, voltmeter, and automatic safety protections against overload and dry run. Pumps and motors shall be from reputed make and suitable for continuous outdoor duty.
3. The contractor shall provide adequate storage facilities, either as overhead or ground-mounted tanks of suitable capacity, fabricated in reinforced concrete or UV-stabilized HDPE material. The total storage capacity shall be designed to meet at least one complete cleaning cycle of the solar plant.
4. Suitable water treatment system such as softening, filtration, or reverse osmosis (RO), may be installed for module cleaning to ensure water quality as per module manufacturer's recommendations.
5. Mandatory permissions for bore well drilling and water use shall be obtained by the Contractor from competent local authorities.
6. All electrical equipment (pumps, panels, etc.) shall be earthed as per IE Rules/Acts and local grid codes.

25.4 RELIABILITY AND MAINTAINABILITY

1. The system shall be designed with redundancy in pumping and distribution, ensuring cleaning operations can continue in case of partial system outage.
2. Sub-systems shall be interconnected through isolating valves to provide operational flexibility.
3. The system shall be designed for a minimum service life of 25 years, with pumps and water treatment systems considered replaceable items during O&M.

26. SAFETY MANAGEMENT

1. Bidder shall submit the Safety Plan and the Safety Coordination Procedure as per the requirement of the bidding documents.
2. During the execution of the contract, the bidder and it's sub-vendor(if any) shall follow safety procedures for the safety of the personnel and the equipment during erection, testing, commissioning, operation and the maintenance during the contract period as per the regulatory requirements, requirements mentioned in the bidding documents, and original equipment manufacturer's recommendations.
3. All the expenses, charges towards compliance of the safety norms by the bidder as per the Safety Plan, Safety Policy, and the Safety Coordination Procedures are deemed to be included in the bid price. No additional claims shall be entertained towards meeting the safety requirements. Minimum price to be quoted for 'Safety Aspects/ compliance to Safety Rules' shall be as per relevant clause of bidding document.
4. Safety sign board to be provided near outdoor transformer yard, HT/LT switchgear, BESS, elephant fencing, and all such risk zone areas.

27. CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

27.1 General Requirements

1. The intent of the specification is to define the functional & design requirements for the CCTV System meant for gathering video information from the various areas of the power plant with display and recording facilities with night vision and motion sensors as per requirement.
2. The Contractor shall be responsible for selection, design, engineering, manufacture, testing at manufacturer's works/site, installation of all the equipment supplied as covered in this specification and commissioning of the system meeting the intent & functional requirements of the specification. All the power supply (UPS), cables, cable trays, power packs, erection hardware (viz. junction boxes, brackets glands, nut-bolts, conduits etc.) and mounting are also included in Contractor's scope.
3. The Contractor's scope shall also include successful demonstration of functional requirements specified herein complete in all respects and shall guarantee satisfactory performance of the equipment under stipulated variations of voltage and frequency.

4. The bidder should offer new (Not refurbished cameras), Obsolete cameras and not an end-of-life product which shall be verified by the owner during detailed engineering .
5. The number of camera units, servers, network switches, wireless equipment etc. and their locations shall be finalized during detailed engineer for effective functional requirements.
6. Any other equipment, module, software required for the safe and satisfactory operation, control, protection, monitoring, testing and maintenance of the system shall also be included by the Bidder within the lump sum quoted price.
7. The equipment furnished under this section shall meet the requirements of all the applicable international codes and standards or their latest amendment Codes and Standards. Camera certification has to be CE/FCC/UL or equivalent.
8. Bidder/Integrator shall provide project specific Authorization from the OEM incorporating the fact that the OEM shall provide technical support/ troubleshooting during commissioning and operation of the system and ensure that the maintenance is being done by the authorized agencies/personals till the completion of the Warranty. equivalent.
9. Comprehensive warranty for 10 years to be provided for complete CCTV offerings.
10. Bidder Shall offer CCTV complying to the regulatory requirement like STQC and others as mandated by nodal agencies with latest amendments.

27.2 POWER SUPPLY ARRANGEMENT

1. Arranging for power supply for cameras and CCTV accessories shall be bidders' responsibility. The CCTV System along with all its components i.e., network switches, storage devices, servers, LAN switches, cameras etc. shall be powered from UPS system. Power Supply requirement if any from the bidder from existing facilities shall be seen based on availability The contractor shall also provide local power distribution boxes as required for sub-distribution of UPS supply.
2. For cameras to be located in remote areas where the UPS power supply cannot be extended due to voltage drop etc., then such cameras can be grouped and fed from mini-UPS. Individual mini-UPS shall be provided for the cameras which cannot be grouped. The contractor shall also provide local power distribution boxes as required for sub-distribution of supply from these mini-UPS to cameras. The location of mini-UPS & power distribution scheme shall be finalized during detail engineering. Powering of the Cameras through POE shall also be acceptable subject to reliability and the same shall be verified during detailed engineering.

3. If the offered equipment is operating at voltage level other than what is available as auxiliary supply, the Contractor shall provide all required hardware, to make the offered system compatible with specified power supply arrangement.

27.3 DESIGN, TECHNICAL REQUIREMENTS AND CYBER SECURITY

1. The CCTV system shall be able to provide surveillance of different locations in the plant like all entry/exit gates, BESS in entire layout ,Office building (Indoor and Outdoor) if applicable and all across the periphery. . Bidder to consider adequate number of cameras to ensure that no area across the periphery is left uncovered at a time. The same shall be reviewed during the design engineering .

   Other strategic locations if any shall be decided during detailed engineering design. The exact locations shall be finalized during detailed engineering stage depending on the CCTV offered. Any kind of terminal equipments and items required for successful commissioning of the CCTV system shall be in the bidder's scope.

   CCTV system shall be designed as a standalone IP based network architecture. The system shall use video signals from different cameras at different locations, process the video signals for viewing on monitors at different locations and simultaneously record all the video streams using H.264 or better compression technique. Joystick and mouse-keyboard controllers shall be used for Pan, Tilt, Zoom and other functions of desired cameras.

2. Camera and database servers shall offer both video stream management, video stream storage management. These servers shall also manage and store configuration information/database for the whole system. Recording frame rate & resolution in respect of individual camera shall be programmable. It shall be possible to view and record at different resolutions and frame rates and this shall be individually programmable on every camera.
   It shall be possible to take back-up of system configuration and database on portable media device and restoring the same if required.

3. System shall ensure that once recorded, video cannot be altered.

4. Camera server shall be provided with a minimum of 28 TB of storage space to store recordings of all cameras. All recordings shall have camera ID, Location, Date and time of recording. The minimum storage days shall be 30 days @25 FPS

at 1080p. Accordingly, the calculation of storage shall be verified during detailed engineering

5. It shall be possible to view, record, search and replay simultaneously without affecting the performance of the system.
6. The system supplied shall be complete in all respects for reliable performance. The Contractor shall submit the detailed block schematic, video, signal & power wiring diagram, describing the connections between the network switch/camera server Systems and various cameras, monitors, keyboard, and joystick.
7. The camera & Video Management Software shall conform to ONVIF profile S, G,T And M or latest available applicable ONVIF profile at the time of detail engineering.
8. The camera OEM Should have valid H.265 HEVC Certificate and should be listed on following official website of HEVC.
9. The network cameras supplied must be manufactured in accordance with the ISO 9001&14001 standards.
10. Camera to be provided along with all the components / parts / assembly /software used in the offered hardware and software all the latest cybersecurity regulation and other certifications as applicable with latest amendments thereof. It shall also be checked/verified to ensure that the camera should not be complying to GB28181, GB/T 28181-2011; GB/T28181-2011; GBT 28181-2011; GBT28181-2011 standards. There should be no option to activate or deactivate these standards in the camera web page/settings.

27.4 DETAILED DESCRIPTION OF THE SYSTEM COMPONENTS:

Application Software for Video Monitoring, Recording & Management.

1. The application software shall be used to display, store, control & manage the entire surveillance system.
2. It shall be possible to control all cameras i.e., PTZ, auto/manual focus, selection of presets, video tour selection etc. The software shall support flexible 1/2/4 windows split screen display mode or scroll mode on the display monitors for live video.
3. The system shall support video analytics in respect of the following server/edge based.

    i. Video motion detection,
    ii. Auto tracking

iii. Object classification and tracking
iv. Line crossing

The feature can be an integral part of camera or a part of camera server. The features shall be user configurable for each camera. It shall be possible to activate recordings automatically based on events generated by video analytics. These events shall also be logged and suitably alarmed on the monitors.

Cameras:

All the cameras shall be color, suitable for day and night surveillance and network compatible. There will be two types of cameras viz. PTZ & Fixed. PTZ cameras shall be high speed integrated dome type.
The camera shall be directly connected to network and use of external encoder for connecting to network is not acceptable. The cameras shall be rugged, high performance color cameras. These cameras shall provide high resolution and high sensitivity suitable for operation in a power plant, both in natural and artificial lighted areas.

Detailed technical specification is given below.

PTZ Dome Cameras
High Definition (HD) PTZ cameras

Image Device	1/2.8-1/3" Progressive scan CMOS
Lens	4.45-4.7 /- 130-137 mm focal length
Optical Zoom	30x or better
Digital Zoom	12x or better
Number of Pixels/Effective resolution	1920X1080 (Full HD)/2 MP at 25/30 IPS
Video compression	H.264, H.265 Main Profile/High profile
Sensitivity	color mode 0.6 lux , B/W mode 0.04lux @30IRE, F1.6
Horizontal Angle of view	55.4 deg(wide)- 3.5 deg (Tele) minimum
Focus	Auto with Manual Override
Iris Range	F1.6-F2.9
Iris Control	Auto with Manual Override

IR Range	250 Meters
Back Light Compensation	Required
White Balance	Automatic with mode selection options
Electronic Shutter	1/50 to 1/10000 Auto
S/N Ratio	>50dB
Audio	Full Duplex or 2-way
Automatic Gain Compensation	Up to 18 dB
Power Supply	The camera power supply should preferably be of the same make as that of camera and suitable for the model no. offered. If the Power supply from the Camera OEM is not available, approval for the power supply shall be accorded during detailed engineering.
Gain Control	Auto/Off
Day/Night selection	Auto On-Off
IR cut-filter	Yes
Protocols	IPV4/IPV6, RTP, UDP, TCP, IP, HTTP, HTTPS, FTP, DHCP, IGMP V2/V3, ICMP, ARP, SMTP, SNTP, SNMP, MQTT or equivalent.
Security	Password protection, Digest authentication, camera to boot with authorized firmware.
Auto Resume after Power Failure	Yes
Multiple Streams Operating resolution	H.264 /H.264 & H.264/Motion JPEG, H.265 with HEVC Certificate. 4 streams at 25 FPS in H.265/H.264
Analytics	Motion detection, Temper detection and etc. .
PoE supply IEEE 802.3af compliant or better	Yes

Rate Control	VBR/CBR
Cybersecurity requirement.	This shall comply with all applicable cybersecurity laws, regulations, and their latest amendments in Fiji. In the absence of relevant legislation, regulations, or policies in Fiji, the applicable AS/NZS standards shall be adopted as the reference framework.
Other Features	
	On screen Menu display and, WDR 120 dB, ONVIF Profile G,S,T and M compliant.
WDR	Automatic Picture Enhancement to give a balanced picture where there is too much/too little light
	Minimum 2 Alarm I/Ps & 1 alarm output
PTZ Specifications	
Pan	360 Deg Continuous
Tilt	± 90 deg.
Manual Tilt Speed	0.1 deg/sec to 280 deg/sec
Manual Pan Speed	0.1 deg/sec to 250 deg/sec
Preset Positions	Minimum 256
Preset Pan Speed	280 deg/sec min
Preset Tilt Speed	250 deg/sec min
Ambient Temperature Range	-10 °C to 55 °C

Fixed Cameras

High Definition (HD) Fixed Camera

Image Device	1/2.8-1/3" Progressive scan CMOS
Number of Pixels	1920X1080 (Full HD)/2 MP at 25/30 FPS

Sensitivity (at f1.2,6dB)	0.21 Lux color & 0.05 Lux B/W(at 30IRE)
Lens	Varifocal Lens f=8-50/11-29 mm, Board/CS-Mount or Motorized 3.00-9.00 mm
Lens Mount	Board/CS-Mount/Motorized.
Focus	Auto with Manual Override
Multiple Streams	4 streams at 2MP, 25 FPS in H.264/H.265
IR Range	50 mtr.(Minimum)
Iris Range	1.7
Audio	Full Duplex or 2-way
IR cut-filter	Yes
Protocols	IPV4/IPV6, RTP, UDP, TCP, IP, HTTP, HTTPS, FTP,DHCP, IGMP V2/V3, ICMP, ARP, SMTP, SNTP, SNMP, MQTT or equivalent
Security	Password protection, Digest authentication, camera t o boot with authorized firmware.
Iris Control	Auto with Manual Override
Analytics	Motion detection, Temper detection, and additional analytics as available.
PoE supply IEEE 802.3af compliant	Yes
SD/SDHC/SDXC in Camera (For Local alarm recording & scheduled local recording)	Yes, minimum 256 GB capability
Rate Control	VBR/CBR
Back Light Compensation	Required
White Balance	Automatic with mode selection options
Electronic Shutter	1/50 to 1/10000 Auto
S/N Ratio	>50dB

Automatic Gain Compensation	Up to 18 dB
Power Supply	The camera power supply should be of the same make as that of camera and suitable for the model no. offered. If the Power supply from the Camera OEM is not available, power supply shall be endorsed by the OEM.
Gain Control	Auto/Off
Day/Night selection	Auto On-Off
Other Features	
	WDR 120 dB, ONVIF Profile G,S,T and M compliant.
WDR	Automatic Picture Enhancement to give a balanced picture where there is too much/too little light
	Minimum One Alarm I/P Minimum One Alarm O/P
Ambient Temperature Range	-10 °C to 55 °C

Camera Housing & Mount

- All the cameras and accessories are to be housed in Weather Proof IP 65 environmental housing made of aluminum and Sun shroud. The housing, with heater and blower installed, shall provide protection for camera/lens assemblies in the ambient temperature range of - 0 deg. C to 50 deg. C.
- The camera mount, camera housing and camera power supply should be of the same make as that of camera and suitable for the model no. offered as specified by the manufacturer.

Keyboard & Joystick

The keyboard shall have full function used for system control and programming for selection of various Network switches, camera/database servers, camera functions including pan, tilt and zoom lens controls and shall be ergonomically designed. Joystick shall be provided for achieving all control functions.

Workstation

Operators work station & network switch station shall be in Control Room or as finalized during the detailed engineering. The size of the display screen shall be minimum 55 inches or inline to the requirement for the complete camera coverage in the screen. Bidder must ensure that the LED screen pixel density shall match with the offered camera pixel density or higher. Bidder to provide as many LED screens as required to technically satisfy the requirements to suitably accommodate the videos from the entire CCTV installed in the field.

Wireless connection Equipment (For camera specified on wireless connectivity):

If contractor offer any camera with wireless connectivity, Access points for these cameras shall be mounted on lighting mast/pole. Wireless equipment and type of wireless connectivity shall be decided during detailed Engineering. Wireless communication for the above should be subscribing to the latest Cyber security standards including encryption. The wireless modem should support dynamic encryption techniques.

Network Switch:

All the network switches shall be of high quality and shall be sized to meet the functional requirements as specified. The common switch to which all networks are connected shall be Layer-III switch/router. All the interconnecting cables between network switches shall be fiber optic only. All fiber optic cables shall be terminated directly to network switches through optical fiber port without using media converters. Bidder to ensure that minimum 100% cores are kept as spares in all type of optical fiber cables. The network switches shall be able to work in the temperature range of -10 C to +55 deg C.

SERVER SPECIFICATION

- Minimum specification of the server to be provided shall be as per the following criteria:
- Processor - Xeon min Octa core
- CPU / Clock speed 3.4 Ghz.

- RAM: DDR4 or better, 16 GB expandable upto 32 GB.
- Hard disk - 8 TB x 4 SSD.
- Minimal Internal storage: 32 TB for storing minimum 30 days recording The minimum storage days shall be 30 days @25 FPS at 1080p. Accordingly, the calculation of storage shall be verified during detailed engineering.
- Storage Drive - 16x or higher for server - SSD R/W drive
- Storage Controller - RAID 5 Controller
- Operating System: Microsoft Windows latest
- Power Supply: Redundant.
- Software: Anti- Virus, Network security etc. as per the requirement during detailed engineering etc.

CABLES:

Cables shall be of FRLS PVC sheathed cables for use in CCTV and shall conform to latest edition of Indian/International standards. Fiber optic cables are to be provided (as applicable). Optic Fiber cable shall be 8 cores, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor /indoor application so as to prevent any physical damage . All the cables and the hardware required for powering the system are also in the scope of Contractor. All cables required for interfacing alarm contact inputs (to be provided by employer) to CCTV system are also in scope of contractor.

For estimation of cable quantities, erection hardware, hardware for wireless communication etc., the Bidder shall refer to General Layout Plant, Equipment Location Plans drawings & other relevant drawings to be finalized during detailed engineering. All the cables are to be provided by the Contractor on as required basis.

CABLES: Location of CCTV:

Bidder to note:

- Location of the CCTV cameras shall be reviewed during detailed engineering.
- The relevant drawings pertaining to location and the location of the console shall be finalized during the detailed engineering.

28. MANDATORY SPARES

28.1 GENERAL

The general requirements pertaining to the supply of mandatory spares is as under.

1. The bidder shall indicate the prices for each and every item (except for items not applicable to the bidders design) in the 'Schedule of mandatory Spares' whether or not he considers it necessary for the Owner to have such spares. If the bidder fails to comply with the above or fails to quote the price of any spare item, the cost of such spares shall be deemed to be included in the contract price. The bidder shall furnish the population per unit of each item in the Bid Forms and Price Schedules. Whenever the quantity is mentioned in "sets" the bidder has to give the item details and prices of each item.
2. Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the station (project), unless specified otherwise, and the fraction will be rounded off to the next higher whole number.
3. Wherever the requirement has been specified as a 'set' it will include the total requirement of the item for a unit, module or the station or as specified. Where it is not specified a 'set' it will include the total requirement of the item for a unit, module or the station or a as specified. Where it is not specified a 'set' would mean the requirement for the single equipment/system as the case may be. Also one set for the particular equipment. e.g. 'set' of bearings for a pump would include the total number of bearings in a pump. Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.
4. The Owner reserves the right to buy any or all the mandatory spares parts.
5. The prices of mandatory spares indicated by the Bidder in the Bid Proposal sheets shall be used for bid evaluation purposes.
6. All mandatory spares shall be delivered at site at least two months before scheduled commissioning of the solar plant. However, spares shall not be dispatched before dispatch of corresponding main equipment.
7. Wherever quantity is specified both as a percentage and a value, the Bidder has to supply the higher quantity until and unless specified otherwise.
8. The Mandatory Spares shall be handed over to the Bidder during O&M Period for use in the Plant Capacity Block through an Indemnity Bond (Format Attached). The spares shall be replenished by the bidder as and when it is used.

9. The spares in total quantity shall be returned to the Employer in working condition at the end of the O&M Period.

A	Mandatory Spares		
1	Solar Photovoltaic (SPV) Modules	0.025% of total DC capacity	
2	Power Conversion System		
2a.	BESS PCS	1 No. of each make/type*	
2a.	Solar Inverter	1 No. of each make/type*	
3	MCCB	2 nos. of each type and rating	
4	33kV Circuit Breakers(For metal enclosed swgr in ICOG/sub pooling switchgear)	1 no. of each type for interchangeable rating	
7	Power pack for HT Swgr if offered for Project	10% of total population or 2 Nos, whichever is higher	
8	33 kV Current Transformer for HT switchgear	2 no. of each type and rating	
9	33 kV Potential Transformer for HT switchgear	2 no. of each type and rating	
10	33 kV Bus Potential Transformer	2 no. of each type and rating	
11	33 kV Surge Arrestor for HT switchgear	2 no. of each type and rating	
12	Earthing Trolley	1 no. of each type and rating	
13	Numerical relay for 33kV HT Switchgear(Inverter stations and Main Pooling)	1 no. of each type	
14	33kV Switchgear-Voltage Detecting Insulator (VDI) and Voltage Presence Indicator(VPI)	10% of total population	
15	Electronic Cards for PCU	5% of total population for each type	

16	IGBT Unit for PCU	5% of total population	
17	DC/Semiconducting Fuse	5% of total population	
18	AC Fuse of rating more than 10 Amp	25 nos. of each rating	
19	String Combiner Box	0.5% of total population	
20	SCADA ethernet switch	5% of total population for each type	
21	SCADA firewall getaway	1 nos. of each type	
22	Module Connector Set (Male & Female) with wire	set	200
23	DC Cable (SPV Module to SCB)	km	5
24	DC Cable (SCB to PCU) of highest size(if applicable)	km	2
25	HT Cable 33kV of highest size **(if applicable)**	km	1
26	Auxiliary transformer (Highest size)	1 No	
27	**Spares related to UPS/Battery charger**		
27.1	UPS/Battery charger for inverter station/sub pooling system	5% of total population for each type and rating	
27.2	Electronic Cards for UPS/ battery charger (inverter station and CMCS)	5% of total population for each type and rating	
27.3	Spare Battery bank for inverter station/sub pooling system UPS/charger with mounting rack (To be kept in CMCS battery room)	1 set	
28	**Spares related to Inverter Transformer (replaceable for all ratings supplied under package)**		
28.1	Inverter Duty Transformer (of higher size and replaceable for all ratings supplied under package)(BESS & SOLAR)	1No.	1

28.2	Set of Valves for Inverter transformer	set	2 Nos. of each type & rating
28.3	WTI with contacts of Inverter transformer	Nos.	
28.4	OTI with contacts of Inverter transformer	Nos.	
28.5	Buchholz relay complete of Inverter transformer	Nos.	
28.6	Pressure Relief Device of Inverter Transformer	Nos.	
28.7	Magnetic Oil Gauge (MOG) of Inverter Transformer	Nos.	
28.8	HV and LV Bushing with metal parts and gaskets of Inverter Transformer(Each Type)	Nos.	
29	**BESS Spares**		
29.1	Battery Packs/ Modules	1 % of Total Population	
29.2	Bidirectional PCS	1 No. of Each Type/Make	
29.3	Fire and Smoke Sensor	5 Set of Each Type	
29.4	PCS IGBT Module	2 Sets	
29.5	All electronic cards and cooling Fan	1 % of Total Population	
29.6	Numerical relays, Contactor & Other Relay	1 % of Total Population	
29.7	HV & LV fuses	5% of Total Population	
29.8	EMS/SCADA Controller	1 Nos.	
29.9	Isolator/Breaker	2 NO. OF Each type & rating	
29.10	Networking Switch	1 Nos.	
29.11	PQ Meter(class-A type)	No	1

29. Major Bought Out Items for Solar+BESS Project at Seaqaqa, Fiji:

Sl. No.	Equipment
1	Solar PV Module
2	Module Mounting Structure
3	DC Cables
4	AC Cables(HT & LT)
5	Solar Inverter
6	Inverter Duty Transformer
7	Auxiliary Transformer
8	HT Switchgear (33 KV)
9	LT Switchgear
10	Weather Monitoring System including Cloud Monitoring System
11	SCADA, PPC & EMS
12	BESS with BMS
13	BESS PCS
14	Digital Radio communication system
15	SCADA, Controllers & EMS for Regional Control Centre
16	Fire Detection & Monitoring System
17	CCTV
18	Earthing & Lighting Protection System
19	UPS, Battery Charger & Battery System
20	Harmonic Filter (If Applicable)
21	Energy & Power Quality Meter
22	Illumination System
23	String Combiner Box
24	Misc. Any other system/Equipment not specified above

Section 5

Forms of Tender

Section 5: Form of Letter of Tender

5.1 Form of Letter of Tender

NAME OF CONTRACT: Supply, Install and Commission Solar PV with Battery Energy Storage System (BESS) for 12MWac PV with BESS Project in Seaqaqa, Vanua Levu (no. MR87 /2026)

TO: Jitendra Reddy
The Manager - Procurement, Inventory & Supply Chain
Energy Fiji Limited
2 Marlow Street, Suva, FIJI.

We have examined the Conditions of Contract, Employer's Requirements, Schedules, the Contract Data and Addenda Nos. _____ for the above-named Contract and the words and expressions used herein shall have the meanings assigned to them in the Conditions of Contract. We have examined, understood and checked these documents and have ascertained that they contain no errors or other defects. We accordingly offer to design, execute and complete the Works and remedy any defects therein, in conformity with such documents and our enclosed Tender (including this letter), for the lump sum price of:

_____
[currency and amounts in figures]

_____
[currency and amounts in words]

We agree to abide by this Tender until 180 days after the Deadline for Submission of Tenders and it shall remain binding upon us and may be accepted at any time before that date.

If this offer is accepted, we will provide the specified Performance Security, commence the Works as soon as is reasonably practicable after the Commencement Date, and complete the Works in accordance with the above-named documents within the Time for Completion. We guarantee that the Works will then conform with the Schedule of Performance Guarantees.

We understand that you are not bound to accept the lowest or any tender you may receive.

Signature _____ in the capacity of _____

duly authorised to sign tenders for and on behalf of _____

Address: _____

Date: _____

5.2 Contract Agreement

This Agreement made the _____ day of_____ _____

Between _____ of _____ (hereinafter called "the Employer") of the one part,

and _____ of _____ (hereinafter called "the Contractor") of the other part

Whereas the Employer desires that the Works known as Supply, Installation and Commissioning of Solar PV with Battery Energy Storage System (BESS) for 12MWac PV with BESS Project in Seaqaqa, Vanua Levu (no. MR87/2026) should be executed by the Contractor, and has accepted a Tender by the Contractor for the execution and completion of these Works and the remedying of any defects therein, for the lump sum Contract Price of:

_____

[currency and amounts in figures]

_____

[currency and amounts in words]

The Employer and the Contractor agree as follows:

1. In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the Conditions of Contract hereinafter referred to.

2. The following documents shall be deemed to form and be read and construed as part of this Agreement:

(a) The memoranda annexed hereto (which includes a breakdown of the Contract Price)

(b) The Conditions of Contract

(c) The Employer's Requirements

(d) The completed Schedules

(e) The Tender and

(f) The JV Undertaking. *

* [if the Contractor constitutes an unincorporated JV, otherwise delete]

3. In consideration of the payments to be made by the Employer to the Contractor as hereinafter mentioned, the Contractor hereby covenants with the Employer to design, execute and complete the Works and remedy any defects therein, in conformity with the provisions of the Contract.

4. The Employer hereby covenants to pay the Contractor, in consideration of the design, execution and completion of the Works and the remedying of defects therein, the final Contract Price at the times and in the manner prescribed by the Contract.

[5. The Contract shall come into full force and effect on the date when the following conditions are satisfied:

[List of pre-conditions]

The Employer shall promptly confirm to the Contractor the date on which alt these conditions have been satisfied. If any of these conditions has not been satisfied within days of the above-mentioned date on which this Agreement is made, this Agreement shall be void and ineffective and any securities issued in relation to the above Works shall be returned. _ _____ optional]

[5. The Commencement Date shalt be _____ optional]

In Witness whereof the parties hereto have caused this Agreement to be executed the day and year first before written in accordance with their respective laws.

SIGNED by: _____ Witness: _____

for and on behalf of the Employer in the presence of Name: _____

Address: _____

Date: _____

SIGNED by: _____ Witness: _____

for and on behalf of the Contractor in the presence of Name: _____

Address: _____

Date: _____

5.3 EXAMPLE FORM OF PARENT COMPANY GUARANTEE

Name of Contract/Contract No.: Supply, Installation and Commissioning of Solar PV with Battery Energy Storage System (BESS) for 12MWac PV with BESS Project in Seaqaqa, Vanua Levu (no. MR87/2026)

Name and address of Employer: Energy Fiji Limited, 2 Marlow Street, Suva, FIJI (together with successors and assigns).

We have been informed that _____ (hereinafter called the "Contractor") is submitting an offer for such Contract in response to your invitation, and that the conditions of your invitation require his/her offer to be supported by a parent company guarantee.

In consideration of you, the Employer, awarding the Contract to the Contractor, we (name of is parent company) irrevocably and unconditionally guarantee to you, as a primary obligation, the due performance of all the Contractor's obligations and liabilities under the Contract, including the Contractor's compliance with all its terms and conditions according to their true intent and meaning.

If the Contractor fails to so perform his/her obligations and liabilities and comply with the Contract, we will indemnify the Employer against and from all damages, losses and expenses (including legal fees and expenses) which arise from any such failure for which the Contractor is liable to the Employer under the Contract.

This guarantee shall come into full force and effect when the Contract comes into full force and effect. If the Contract does not come into full force and effect within a year of the date of this guarantee, or if you demonstrate that you do not intend to enter into the Contract with the Contractor, this guarantee shall be void and ineffective. This guarantee shall continue in full force and effect until all the Contractor's obligations and liabilities under the Contract have been discharged, when this guarantee shall expire and shall be returned to us, and our liability hereunder shall be discharged absolutely.

This guarantee shall apply and be supplemental to the Contract as amended or varied by the Employer and the Contractor from time to time. We hereby authorise them to agree any such amendment or variation, the due performance of which and compliance with which by the Contractor are likewise guaranteed hereunder. Our obligations and liabilities under this guarantee shall not be discharged by any allowance of time or other indulgence whatsoever by the Employer to the Contractor, or by any variation or suspension of the works to be executed under the Contract, or by any amendments to the Contract or to the constitution of the Contractor or the Employer, or by any other matters, whether with or without our knowledge or consent.

This guarantee shall be governed by the law of the same country (or other jurisdiction) as that which governs the Contract and any dispute under this guarantee shall be finally settled under the Rules of Arbitration of the International Chamber of Commerce by one or more arbitrators appointed in accordance with such Rules. We confirm that the benefit of this guarantee may be assigned subject only to the provisions for assignment of the Contract.

Signed by	_____	Signed by	_____
Name	_____	Name	_____
Date	_____	Date	_____

5.4 Example form of Tender Security

(for Reference Only – Not Required for This Tender)

Guarantee No.: _____

The Guarantor: _____

[insert name and address of place of issue, unless indicated in the letter head]

Name of Contract/Contract No.: Supply, Installation and Commissioning of Solar PV with Battery Energy Storage System (BESS) for 12MWac PV with BESS Project in Seaqaqa, Vanua Levu (no. MR87/2026)

The Beneficiary (the "Employer"): Energy Fiji Limited, 2 Marlow Street, Suva, FIJI.

We have been informed that _____[name and address of the Tenderer]_____ (hereinafter called the "Applicant") is submitting an offer for such Contract in response to your invitation, and that the conditions of your invitation (the "Conditions of Invitation", which are set out in a document entitled Instructions to Tenderers) require his/her offer to be supported by a tender security.

At the request of the Applicant, we _____[insert name of Guarantor]_____ hereby irrevocably undertake to pay you, the Beneficiary/Employer, any sum or sums not exceeding in total the amount of _____ US$ 1000 *one thousand US dollars* _____upon receipt by us of your demand in writing and your written statement (in the demand) that:

(a) the Applicant has, without your agreement, withdrawn his/her offer after the latest time specified for its submission and before the expiry of its period of validity, or

(b) the Applicant has refused to accept the correction of errors in his/her offer in accordance with such Conditions of Invitation, or

(c) you entered into the Contract with the Applicant and he/she has failed to deliver a performance security complying with Sub-Clause 4.2.1 of the Conditions of Contract.

Any demand for payment must contain your signature(s) which must be authenticated by your bankers or by a notary public. The authenticated demand and statement must be received by us at the following office ___[insert address of office]____ on or before _ [insert the date 35 days after the expiry of the validity of the Letter of Tender]____, when this guarantee shall expire.

The party liable for the payment of any charges: __ Contractor Name ___[insert the name of the party].

This guarantee shall be governed by the laws of _____[insert the law governing the guarantee]____, and shall be subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758.

Signed by _____ Signed by _____

Name _____ Name _____

Date _____ Date _____

5.5 Example form of Performance Security – Demand Guarantee

Guarantee No.: _____

The Guarantor: _____

[insert name and address of place of issue, unless indicated in the letter head]

Name of Contract/Contract No.: Supply, Installation and Commissioning of Solar PV with Battery Energy Storage System (BESS) for 12MWac PV with BESS Project in Seaqaqa, Vanua Levu (no. MR87/2026)

The Beneficiary (the "Employer"): Energy Fiji Limited, 2 Marlow Street, Suva, FIJI.

We have been informed that_____ [insert name and address of the Contractor] (hereinafter called the "Applicant") is your Contractor under such Contract, which requires him/her to obtain a Performance Security.

At the request of the Applicant, we _____ [insert name of Guarantor] hereby irrevocably undertake to pay you, the Beneficiary/Employer, any sum or sums not exceeding in total the amount of _____ [insert in figures and words the maximum amount payable and the currency in which it is payable]_____ (the "Guaranteed Amount") upon receipt by us of your demand in writing and your written statement indicating in what respect the Applicant is in breach of its obligations under the Contract.

[Following receipt by us of an authenticated copy of the Taking-Over Certificate for the whole of the Works under Clause 10 of the Conditions of Contract, the Guaranteed Amount shall be reduced by _____% and we shall promptly notify you that we have received such certificate and have reduced the Guaranteed Amount accordingly.]

Following receipt by us of an authenticated copy of a statement issued by you that, pursuant to Sub-Clause 4.2.1 of the Conditions of Contract, variations or adjustments under Clause 13 of the Conditions of Contract have resulted in an accumulative increase or decrease of the Contract Price by more than twenty percent (20%) of the Contract Price stated in the Contract Agreement, and that therefore the Guaranteed Amount should be adjusted by the percentage specified in the statement equal to the accumulative increase or decrease, respectively, we shall promptly inform you that we have received such statement and have adjusted the Guaranteed Amount accordingly. In the case of a request for a decrease of the amount of the Performance Security, the above statement shall be accompanied by your written consent to such decrease.

Any demand for payment must contain your signature(s) which must be authenticated by your bankers or by a notary public. The authenticated demand and statement must be received by us at the following office _____[insert address of office] _____on or before _____ [insert the date 70 days after the expected expiry of the Defects Notification Period for the Works) (the "Expiry Date"), when this guarantee shall expire.

The party liable for the payment of any charges: __ Contractor Name _____[insert the name of the party]. This guarantee shall be governed by the laws of _____ [insert the law governing the guarantee], and shall be subject to the Uniform Rules for Demand Guarantees, (URDG) 2010 Revision, ICC Publication No. 758.

Signed by	_____	Signed by	_____
Name	_____	Name	_____
Date	_____	Date	_____

5.6 Example form of Performance Security – Surety Bond

Guarantee No.: _____

The Guarantor: _____

[insert name and address of place of issue, unless indicated in the letter head]

Name of Contract/Contract No.: Supply, Installation and Commissioning of Solar PV with Battery Energy Storage System (BESS) for 12MWac PV with BESS Project in Seaqaqa, Vanua Levu (no. MR87/2026)

The Beneficiary (the "Employer"): Energy Fiji Limited, 2 Marlow Street, Suva, FIJI.

We have been informed that_____ [insert name of the Contractor] (hereinafter called the "Principal") is your contractor under such Contract, which requires him/her to obtain a Performance Security.

By this Bond, _____[insert name and address of contractor]_____(who is your Contractor under such Contract) as Principal and:_____[insert name and address of Guarantor] as Guarantor are irrevocably held and firmly bound to the Beneficiary in the total amount of _____[insert in figures and words the maximum amount payable and the currency in which it is payable]_____ (the "Bond Amount") for the due performance of all such Principal's obligations and liabilities under the above named Contract.

[Such Bond Amount shall be reduced by _____% upon the issue of the Taking-Over Certificate for the whole of the Works under Clause 10 of the Conditions of Contract.] (1)

This Bond shall become effective on the Commencement Date defined in the Contract.

Upon Default by the Principal to perform any contractual obligation, or upon the occurrence of any of the events and circumstances listed in Sub-Clause 15.2.1 of the Conditions of Contract, the Guarantor shall satisfy and discharge the damages sustained by the Beneficiary due to such Default, event or circumstances. (2) However, the total liability of the Guarantor shall not exceed the Bond Amount.

The obligations and liabilities of the Guarantor shall not be discharged by any allowance of time or other indulgence whatsoever by the Beneficiary to the Principal, or by any variation or suspension of the Works to be executed under the Contract, or by any amendments to the Contract or to the constitution of the Principal or the Beneficiary, or by any other matters, whether with or without the knowledge or consent of the Guarantor.

Any claim under this Bond must be received by the Guarantor on or before _____ [insert the date six months fatter the expected expiry of the Defects Notification Period for the Works] ____ (the "Expiry Date"), when this Bond shall expire and shall be returned to the Guarantor.

The benefit of this Band may be assigned subject to the provisions for assignment of the Contract, and subject to the receipt by the Guarantor of evidence of full compliance with such provisions.

This Band shall be governed by the law of _____ [insert the law governing] ____being the same country (or other jurisdiction) as that which governs the Contract. This Bond incorporates and shall be subject to the Uniform Rules for Contract Bonds, published as number 524 by the International Chamber of Commerce, and words used in this Bond shall bear the meanings set out in such Rules.

Whereas this Band has been issued by the Principal and the Guarantor on ____[date]___.

Signed by	_____	Signed by	_____
Name	_____	Name	_____
Date	_____	Date	_____

5.7 Example form of advanced payment guarAntee

(for Reference Only – Not Required for This Tender)

Guarantee No.: _____

The Guarantor: _____

[insert name and address of place of issue, unless indicated in the letter head]

Name of Contract/Contract No Supply, Installation and Commissioning of Solar PV with Battery Energy Storage System (BESS) for 12MWac PV with BESS Project in Seaqaqa, Vanua Levu (no. MR87/2026)

The Beneficiary (the "Employer"): Energy Fiji Limited, 2 Marlow Street, Suva, FIJI.

We have been informed that _____[insert name and address of the Contractor]_____ (hereinafter called the "Applicant") is your Contractor under such Contract and wishes to receive an advance payment, for which the Contract requires him/her to obtain a guarantee.

At the request of the Applicant, we _____ [insert name of Guarantor] hereby irrevocably undertake to pay you, the Beneficiary/Employer, any sum or sums not exceeding in total the amount of _____ [insert in figures and words the maximum amount payable and the currency in which it is payable] (the "Guaranteed Amount") upon receipt by us of your demand in writing and your written statement that:

(a) the Applicant has failed to repay the advance payment in accordance with the Conditions of Contract, and

(b) the amount of the advance payment which the Applicant has failed to repay.

This guarantee shall become effective upon receipt [of the first instalment] of the advance payment by the Applicant. The Guaranteed Amount shall be reduced by the amounts of the advance payment repaid to you, as evidenced by your notices issued under Sub-Clause 14.6 of the Conditions of Contract. Following receipt of a copy of each purported notice, we shall promptly notify you of the revised Guaranteed Amount accordingly.

Any demand for payment must contain your signature(s) which must be authenticated by your bankers or by a notary public. The authenticated demand and statement must be received by us at the following office [insert address of office] on or before _____ [insert the date 70 days after the expected expiry of the Time for Completion] (the "Expiry Date"), when this guarantee shall expire.

The party liable for the payment of any charges: ____ Contractor Name _____[insert the name of the party].

This guarantee shall be governed by the laws of _____[insert the law governing the guarantee}, and shall be subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758.

Signed by	_____	Signed by	_____
Name	_____	Name	_____
Date	_____	Date	_____

5.8 Example form of payment guarantee by employer

Guarantee No.: _____

The Guarantor: _____

[insert name and address of place of issue, unless indicated in the letter head]

Name of Contract/Contract No.: Supply, Installation and Commissioning of Solar PV with Battery Energy Storage System (BESS) for 12MWac PV with BESS Project in Seaqaqa, Vanua Levu (no. MR87/2026)

The Beneficiary (the "Contractor"): _____[insert name and address of the Beneficiary]

We have been informed that_____[Insert name and address of the Employer]__(hereinafter called the "Applicant") is required to obtain a bank guarantee.

At the request of the Applicant, we _____ [insert name of Guarantor] hereby irrevocably undertake to pay you, the Beneficiary/Contractor, any sum or sums not exceeding in total the amount of _____ [insert in figures and words the maximum amount payable and the currency in which it is payable] upon receipt by us of your demand in writing and your written statement that:

(a) in respect of a payment due under the Contract, the Applicant has failed to make payment in full by the date fourteen days after the expiry of the period specified in the Contract as that within which such payment should have been made, and

(b) the amount(s) which the Applicant has failed to pay.

Any demand for payment must be accompanied by a copy of _____ [insert list of documents evidencing entitlement to payment and the language in which these documents are to be submitted], in respect of which the Applicant has failed to make payment in full.

Any demand for payment must contain your signature(s) which must be authenticated by your bankers or by a notary public. The authenticated demand and statement must be received by us at the following office [address of office] on or before _ _____[insert the date six months after the expected expiry of the Defects Notification Period for the Works] when this guarantee shall expire.

The party liable for the payment of any charges: __Contractor Name_____[insert the name of the party}.

This guarantee shall be governed by the taws of _____ [insert the law governing

the guarantee] and shall be subject to the Uniform Rutes for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758.

Signed by	_____	Signed by	_____
Name	_____	Name	_____
Date	_____	Date	_____

5.9 Schedules Required from Tenderers

Schedule A: Qualifications of the Tenderer

A	Item & Requirement	Proposed in Tender	Deviations from Employer's Requirements
1			
2			
3			
4			
5			
6			
7			
8			

Schedule B: Key Contractors Personnel

B	Item & Requirement	Proposed in Tender	Deviations from Employer's Requirements
1	Project Manager		
2	Construction Superintendent		
3	Design Manager		
4			

Schedule C: Description of Proposed Works (and any preliminary drawings)

C	Item & Requirement	Proposed in Tender	Deviations from Employer's Requirements
1			
2			
3			

Schedule D: Proposed Major Items

D.1 Civil Works

D.1	Main Components	Proposed in Tender	Deviations from Employer's Requirements
1			
2			
3			
4			
5			
6			
7			

D.2 Mechanical Works

D.2	Main Components	Proposed in Tender	Deviations from Employer's Requirements
16			
17			

Schedule E: Tenderers Proposed Management and Timelines

E	Item & Requirement	Proposed in Tender	Deviations from Employer's Requirements
1			
2			
3			
4			
5			
6			

Schedule F: Schedule for Prices

The following Schedule for Prices is not all-inclusive but intended to provide general guidance for Tenderers to show their itemised costs for the purpose of evaluation of the Lump Sum offer under the Tender. The information provided in this Schedule for Prices shall not be considered the final list of materials and service costs or used for the procurement of the renewable energy system or for detailed final design. The equipment selection and procurement shall be provided by the Tenderer under the Contract. The Tenderer is advised to perform its own due diligence for their proposed design, final list of materials and service costs, and to exercise own professional judgment on materials and service costs, and to consult with suppliers for materials and service costs supplied under the Contract.

IMPORTANT: the itemised costs below shall that incurred by the Employer within the Lump Sum price of the Contract, and this include any and all materials and service costs, contingencies, Contractor overhead, off-shore taxes, fees and duties, and shipping costs & insurances to the site…etc.

Lump Sum for Required Capacities	Unit	Unit Cost	Qty.	Total Price	Source / Comments
(A) Regulatory Costs					
A.1: Land Regulations (Processing & Application Fees)				**Input Sub-Total**	
Planning and Construction Permissions					
Building and Environmental Management Permits					
Insert additional items here					
A.2: Electricity Regulations (Processing & Application Fees)				**Input Sub-Total**	
Licenses for electrical contractor					
Insert additional items here					
Regulatory Costs - Total (A):				**Input Sub-Total**	

Lump Sum for Required Capacities	Unit	Unit Cost	Qty.	Total Price	Source / Comments
(B) Engineering Costs					

B.2: EPC Design Engineering				**Input Sub-Total**	
Additional Site Survey and layout					
Detailed Civil Works Design					
Detailed Mechanical Works Design					
Structural engineering verification visits					
Test drilling and piling					
Other engineering and testing					
Insert additional items here					
Engineering Costs - Total (B):				**Input Sub-Total**	

Lump Sum for Required Capacities	Unit	Unit Cost	Qty.	Total Price	Source / Comments
(C) Mechanical Costs					
C.1: Control Building / Solar PV / BESS / Sync Communications / Security				**Input Sub-Total**	
Solar PV (PV modules / inverters / mounting structures)					
BESS (batteries / PCS / BMS)					
Energy Management System (EMS)					
Single Mode Fiber					
Network switches with SFP slots (native fiber connections)					
Security CCTV and lighting etc.					
Required additional peripherals					
Insert additional items here					

Mechanical Costs - Total (C):				**Input Sub-Total**	

Lump Sum for Required Capacities	Unit	Unit Cost	Qty.	Total Price	Source / Comments
(D) Mechanical Installation Costs					
D.1: Power Transmission Side				**Input Sub-Total**	
Transformer / Switchgear / MV-HV Cabling					
Required additional peripherals					
Insert additional items here					
D.2: Inverter and AC Side of Equipment:				**Input Sub-Total**	
PV Inverters / PCS / AC cabling / controls					
Required additional peripherals					
Insert additional items here					
D.3: Solar PV Equipment				**Input Sub-Total**	
PV Modules / Mounting Strucrures / DC Cabling					
Required additional peripherals					
Insert additional items here					
D.4: BESS and Control Systems				**Input Sub-Total**	
Batteries / BMS / EMS / Control Room / Communications / Security Systems					

Required additional peripherals					
Insert additional items here					
Mechanical Installation Costs - Total (D):				**Input Sub-Total**	

Lump Sum for Required Capacities	Unit	Unit Cost	Qty.	Total Price	Source / Comments
(E) Civil Works Costs					
E.1: Power Transmission Side				**Input Sub-Total**	
Transformer / RMU / Switchgear foundations					
Required additional peripherals					
Insert additional items here					
E.2: On-Site Civil Works plus Installation				**Input Sub-Total**	
Stormwater Culverts & wingwalls (internal road)					
Stormwater open earth drains (>1% slope, width & depth varies)					
PV foundations					
BESS foundations					
Levelling and compaction and fill of land on-site					
Clearing of land					
Seeding (grass) of land					
Required additional peripherals					
Insert additional items here					

Civil Works Costs - Total (E):				**Input Sub-Total**	

Lump Sum for Required Capacities	Unit	Unit Cost	Qty.	Total Price	Source / Comments
(F) Miscellaneous Costs					
F.1: Miscellaneous				**Input Sub-Total**	
Insurance During Construction					
EPC Gap Financing					
Spare parts					
Additional peripherals					
Insert additional items here					

Miscellaneous Costs - Total (F):		**Input Sub-Total**	

Lump Sum for Required Capacities		Total Cost	Applicable VAT
Total Lump Sum (Tender Price)		**Total Lump Sum**	**Total VAT Sum**
Regulatory Costs - Total (A):		**Input Sub-Total**	**Input Sub-Total**
Engineering Costs - Total (B):		**Input Sub-Total**	**Input Sub-Total**
Mechanical Costs - Total (C):		**Input Sub-Total**	**Input Sub-Total**
Mechanical Installation Costs - Total (D):		**Input Sub-Total**	**Input Sub-Total**
Civil Works Costs - Total (E):		**Input Sub-Total**	**Input Sub-Total**
Miscellaneous Costs - Total (F):		**Input Sub-Total**	**Input Sub-Total**

Lump Sum for Additional Capacities		Total Cost	Applicable VAT
All inclusive cost for each additional 1 MWp capacity of the solar PV power station, exceeding the Required Capacities		**Input Sub-Total**	**Input Sub-Total**
All inclusive cost for each additional 1 MWh capacity of the BESS, exceeding the Required Capacities		**Input Sub-Total**	**Input Sub-Total**
Insert additional items here		**Input Sub-Total**	**Input Sub-Total**

The Contract Price shall include all taxes, duties, and other changes imposed outside the Employer's country on the production, manufacture, sale and transport of the Contractor's equipment, Plant, materials and supplies to be used on or furnished under the Contract, and on the services performance under the Contract. The prices bid by the Contractor shall include all customs duties, import duties, with Holding Tax, business taxes, income and other taxes that may be levied in accordance to the laws and regulations in being as of the date 28 days prior to the closing date for submission of bids in the Employer's country on the Contractor's Equipment, Plant, materials and supplies (permanent, temporary and consumable) acquired for the purpose of the Contract and on the services performed under the Contract.

Section 6

Tender Schedules

Schedule-01: Plant Performance

Equipment / System	Sl. No.	Evaluation Parameter	EPC Submission	Remarks
Plant Performance	1	DC:AC Ratio (MWp/MWac)		
	2	Annual Energy Generation (MWh/year)		
	3	Capacity Utilization Factor (CUF %)		
	4	Performance Ratio (PR %)		

Schedule-02: Technical Parameters of PV Module

Equipment / System	Sl. No.	Evaluation Parameter	EPC Submission	Remarks
PV Modules	1	Manufacturer & Model		Manufacturer will be preferred which has experience in typhoon prone areas.
	2	Module Technology (TOPCon/HJT/Mono PERC)		Suitable for Typhoon prone areas.
	3	Module Efficiency (%)		
	4	Mechanical Load Rating		
	5	Product Warranty		

Schedule-03: Technical Parameters of Solar Inverter / PCU

Equipment / System	Sl. No.	Evaluation Parameter	EPC Submission	Remarks
Solar Inverter / PCU	1	Manufacturer & Model		Manufacturer will be preferred which has experience in typhoon prone areas.
	2	Maximum Efficiency		
	3	THD (%)		
	4	Overload Capacity		
	5	IP Rating		
	6	Warranty		

Schedule-04: Technical Parameters of Battery Energy Storage System (BESS)

Equipment / System	Sl. No.	Evaluation Parameter	EPC Submission	Remarks
Battery Energy Storage System (BESS)	1	Battery Manufacturer		Manufacturer will be preferred which has experience in typhoon prone areas.
	2	Round Trip Efficiency		
	3	Battery Cycle Life		
	4	Maximum C-Rate		
	5	Warranty		

Schedule-05: Technical Parameters of Power Conversion System (PCS)

Equipment / System	Sl. No.	Evaluation Parameter	EPC Submission	Remarks
Power Conversion System (PCS)	1	Manufacturer & Model		
	2	Conversion Efficiency		
	3	THD		
	4	IP Rating		
	5	Warranty		

Schedule-06: Technical Parameters of EMS, SCADA & Communication

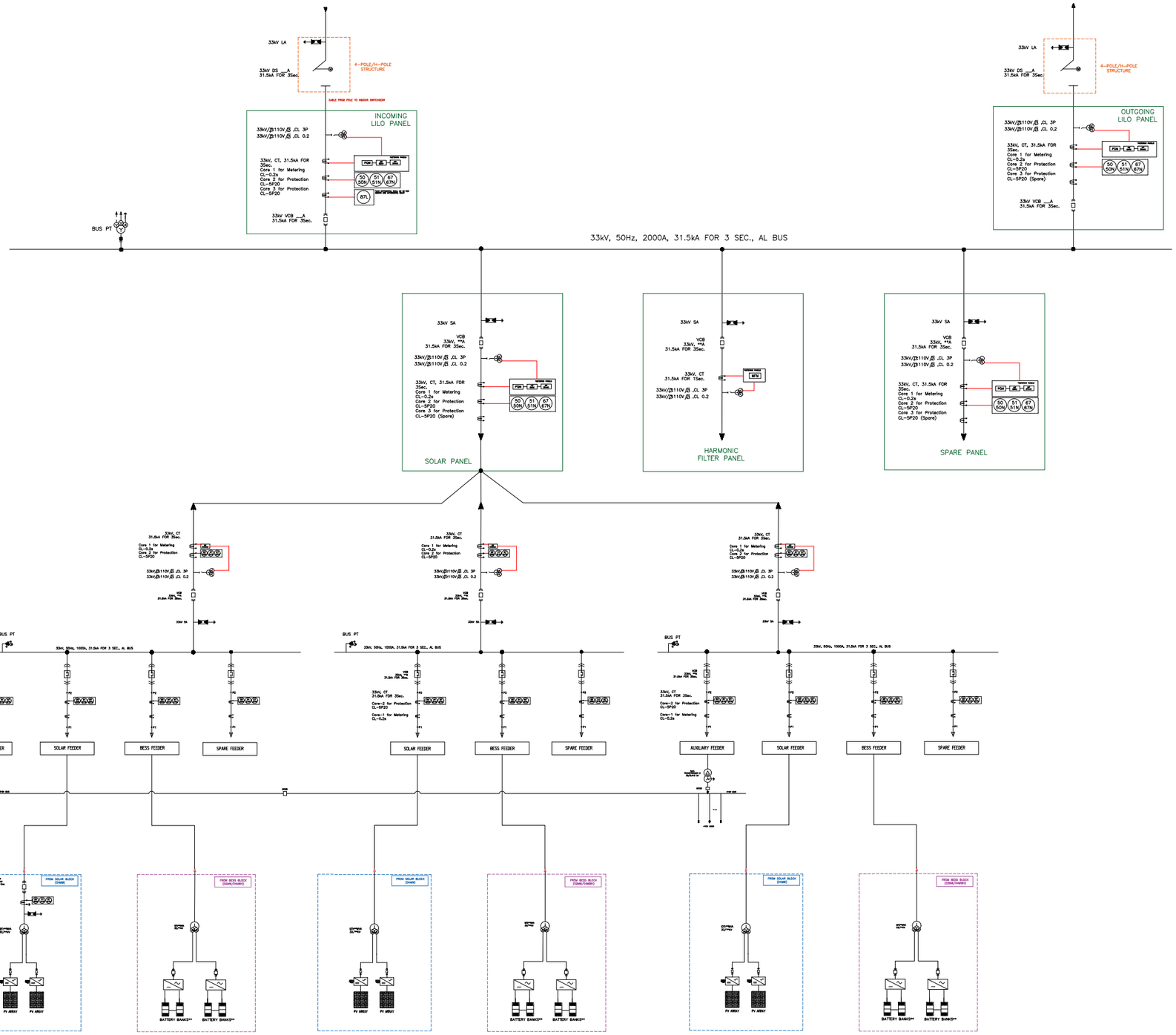
Equipment / System	Sl. No.	Evaluation Parameter	EPC Submission	Remarks
EMS, SCADA & Communication	1	Energy Management System		Preference will be given to manufacturers with demonstrated experience in distributed generation and renewable energy hybrid systems.

Schedule-07: Parameters of Quality, HSE & Project Execution

Preference shall be given to EPC companies with proven experience in the successful execution of Solar PV + Battery Energy Storage System (BESS) projects within microgrids incorporating distributed generation sources. Particular preference shall be accorded to firms that have delivered similar projects in small island nations and isolated grid systems, especially in regions exposed to typhoons, cyclones, hurricanes, or other extreme weather conditions, demonstrating expertise in designing and implementing resilient, reliable, and climate-resilient energy infrastructure.

The EPC contractor shall demonstrate a strong track record in quality management, health, safety and environmental (HSE) performance, and project execution, supported by successful project references. Experience in executing projects on weak or isolated grids, managing complex island logistics, integrating Solar PV, BESS, and conventional generation into stable microgrid operations, and delivering projects safely, on schedule, and in compliance with international standards shall be considered a significant advantage during technical evaluation.

Section 7
Drawings



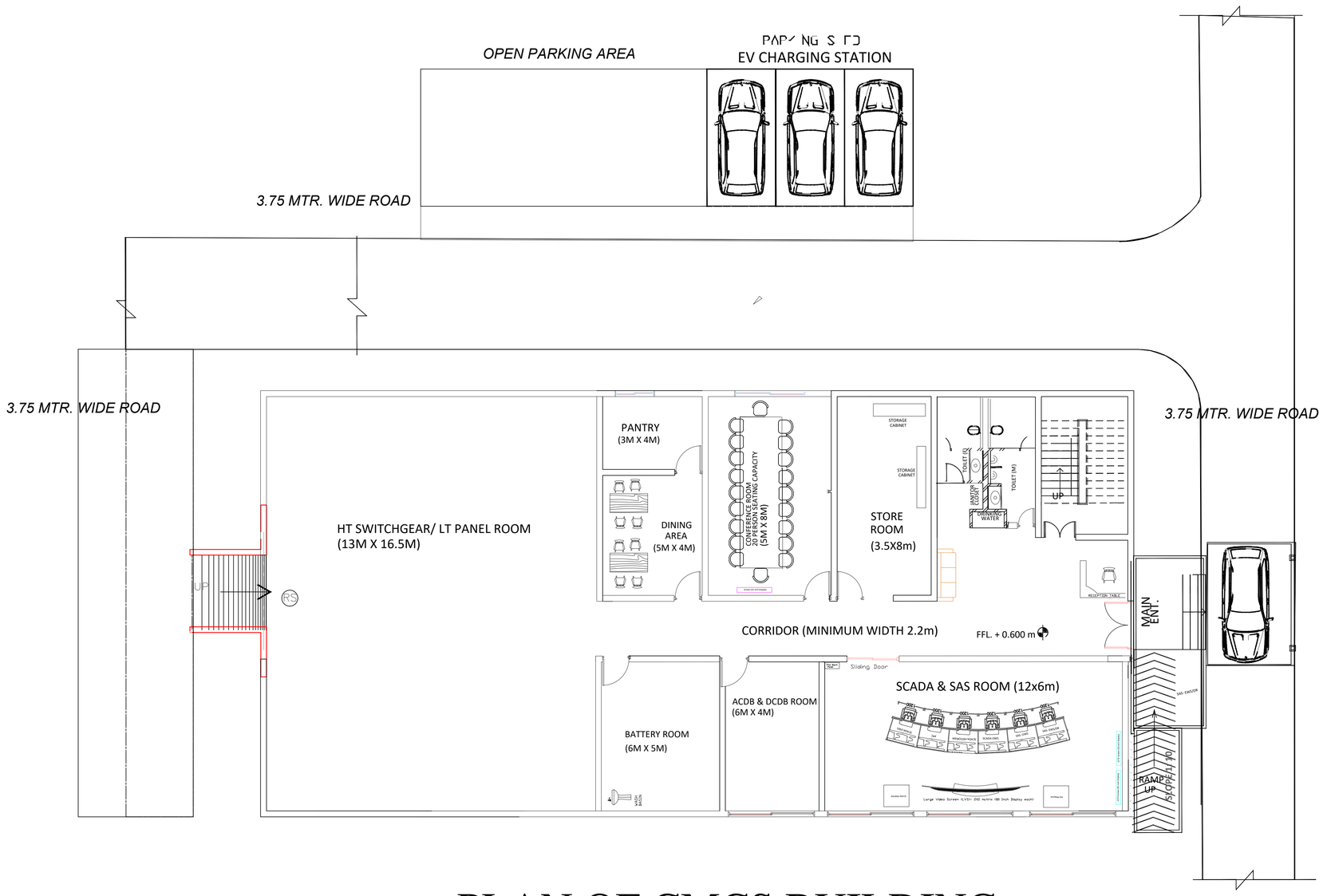
NOTES–

1) SUITABLE UPS AND/OR DC SYSTEM AND OR DG SET WITH BACK UP IS TO BE PROVIDED FOR AUXILIARY POWER SUPPLY FOR PCS AND BESS.
2) THE INVERTER TRANSFORMER ARRANGEMENT SHOWN IS TYPICAL, THE TRANSFORMER CONFIGURATION, VECTOR, IMPEDANCE, INSULATION CLASS ETC AS PER INVERTER MANUFACTURER RECOMMENDATION.
3) BIDDER SHALL USE 33 Kv CABLE FOR CONNECTING FROM LOCAL POOLING SWITCHGEAR /ICOG TO 33 Kv MAIN POOLING SWITCHGEAR.
4) BLOCK SIZE GIVEN IN THE SLD IS TENTATIVE AND MAY BE CHANGED BY BIDDER AS PER SITE CONDITION DURING DETAILED ENGINEERING AFTER APPROVAL FROM OWNER.
5) SUPPLY, ERECTION AND COMMISSIONING OF 33 Kv METERING CABLES AND METERS IN 33 Kv SUBSTATION SWITCHGEAR IS UNDER BIDDERS SCOPE.
6) BIDDER TO PROVIDE REDUNDANT POWER PLANT CONTROLLER AND SUBMIT GRID CONNECTIVITY COMPLIANCE STUDY /REPORT.
7) BIDDER TO INTEGRATE REAL TIME DATA OF ABOVE TARIFF METERS TO METER DATA MANAGEMENT SYSTEM.
8) BIDDER TO PROVIDE NECESSARY ARRANGEMENT TO COMMUNICATE WITH EXITING DG POWER HOUSE & BAGGASE POWER PLANT FOR CONTROLLING & MODULATION OF LOAD FOR GRID STABILITY.
9) NECESSARY COMMUNICATION INFRASTRUCTURE/SOFTWARE ALONG WITH REQUIRED CONTROLLERS ARE IN BIDDER'S SCOPE.
10) THE METALLIC SCREEN/ARMOUR OF CORE AND CONDUCTOR OF HT CABLES SHALL BE CAPABLE OF CARRYING SYSTEM FAULT CURRENT.
11) SOLAR & BESS SCADA OWS/EWS SHALL BE PLACED BY THE BIDDER INSIDE CONTROL BUILDING. REDUNDANT AC AND DC SUPPLY FOR SCADA, UPS AND HT PANEL IS IN BIDDER SCOPE.
12) POWER WILL BE EVACUATED FROM EXISTING 33 Kv LINE PASSING NEAR TO PROJECT AREA. LILO CONNECTION FROM TRANSMISSION POLE TO INDOOR HT POOLING SWITCHGEAR THROUGH H-POLE & HT CABLE AND O/G LINE CONNECTION TO TRANSMISSION POLE SHALL BE CONSIDERED IN THE SCOPE OF BIDDER. ANY AUGMENTATION IN THE PROTECTION SCHEME OF TRANSMISSION LINE AND COMMUNICATION SYSTEM AND SAFETY REQUIREMENT ARE CONSIDERED IN THE SCOPE OF BIDDER.
13) STANDBY METER AND PQM METER OF SULTABLE RATING IS IN THE SCOPE OF BIDDER AS PER EFL REQUIREMENT. LOCATION OF ALL METER SHOWN IS TENTATATIVE AND MAY BE CHANGED AS PER EFL REQUIREMENT.
14) PG TEST AND GURANTEED GENERATION WILL BE CHECKED AT 33 Kv METERING POINT.
15) CONFIGURATION OF POOLING SWITCHGEAR, PV BLOCKS, BESS AND HARMONIC FILTER IS INDICATIVE ONLY. ACTUAL CONFIGURATION SHALL BE IN COMPLIANCE WITH APPLICABLE STANDARDS AND /OR REGULATIONS.

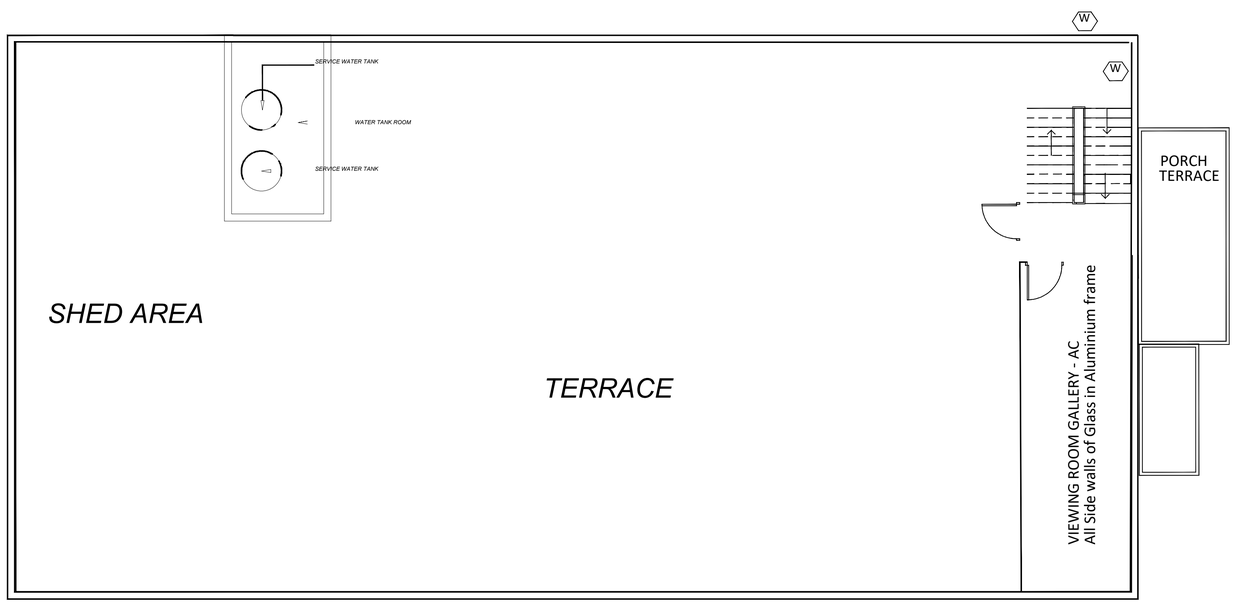
FOR TENDER PURPOSE ONLY

ENERGY FIJI LIMITED

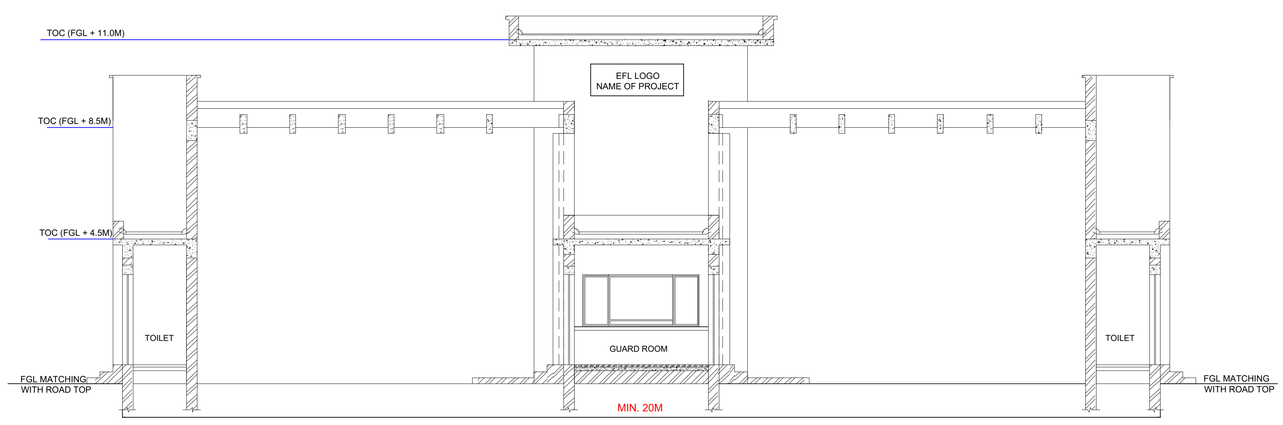
				PROJECT: EPC PACKAGE FOR 12 MWac SOLAR PV WITH BATTERY ENERGY STORAGE SYSTEM (BESS) AT SEQAQA, VANU LEVU , FIJI			
				TITLE: *SOLAR & BESS SLD*			
PREPARED BY:	CHECKED BY:	APPROVED BY:	DATE:	SIZE: A3	SCALE: NTS	DRAWING NO.: ------	REV. NO.: 0



PLAN OF CMCS BUILDING



TERRACE LAYOUT



KEY PLAN FOR GATE COMPLEX

The CMCS building layout shown in the tender drawing is for indicative purpose only. The final room arrangement and dimensions shall be determined by the EPC Contractor based on the selected equipment, operational requirements, maintainability, and future expansion provisions, subject to EFL's approval.

GENERAL NOTES:

1. THE DETAILED CONSTRUCTION & DESIGN DRAWING OF CMCS BUILDING, MEETING MINIMUM REQUIREMENT MENTIONED IN THIS TENDER DRAWING SHALL BE DEVELOPED BY BIDDER AND SUBMITTED TO NTPC FOR REVIEW AND EFL APPROVAL BEFORE START OF WORK.
2. SOME MINOR CHANGES IN DETAILED CONSTRUCTION OF CMCS BUILDING WITH RESPECT TO TENDER DRAWING MAY BE PROPOSED BY BIDDER AS PER RECOMMENDATION OF EQUIPMENT MANUFACTURER, BETTER PERFORMANCE AND LOCATION OF SCADA ROOM AND VIEWPOINT. THE SAME SHALL BE SUBJECT TO NTPC APPROVAL.
3. MINIMUM CLEARANCE BETWEEN BACK SIDE OF ANY FLOOR MOUNTED PANEL AND THE WALL SHALL BE 1000 MM OR MANUFACTURER RECOMMENDATION, WHICHEVER IS HIGHER.
4. MINIMUM WORKING CLEARANCE BEFORE FRONT PANELS OF ANY SWITCHGEAR, PCU OR SIMILAR EQUIPMENT GENERALLY SHALL NOT BE LESS THEN 2200MM.
5. THE HEIGHT OF PARAPET WALL SHALL BE MINIMUM 300 MM ABOVE THE TOP OF ROOF LEVEL. STAINLESS STEEL HAND RAILINGS OF MINIMUM 700 MM HEIGHT SHALL ALSO BE PROVIDED OVER THE PARAPET WALL
6. THE ROOF SLOPE SHALL NOT BE LESS THAN 1:100 AND THE ROOF SHALL BE PROVIDED WITH RCC/PVC WATER GUTTER
7. RCC SUNSHADE OVER THE OPENINGS WITH 300 MM PROJECTION ON BOTH SIDES OF THE OPENINGS. PROJECTION OF SUNSHADE FROM THE WALL SHALL BE MINIMUM 450 MM OVER WINDOW OPENINGS AND DOOR OPENINGS EXCEPT FOR MAIN ENTRANCE DOOR.
8. THE ROOF SHALL HAVE A VIEWING GALLERY/ OBSERVATION DECK FOR PANORAMIC VIEW OF PROJECT
9. ALMIRAHS TO BE PROVIDED IN STORE ROOM FOR STORAGE OF MANDATORY SPARE IED'S, ELECTRONIC CARDS ETC.
10. THE ROOF OF CMCS BUILDING, PARKING SHEDS AND TRANSIT CAMP SHALL BE INSTALLED WITH ROOFTOP SOLAR PV PANELS AND PARKING SHALL HAVE THE PROVISION FOR EV CHARGING.
11. BIDDER SHALL SUPPLY FURNITURE & FIXTURES/FACILITIES FOR ALL ROOMS OF CMCS BUILDING (INCLUDING OWNER'S ROOM, CONFERENCE ROOM, TRANSIT ROOM, WAITING AREA, STOREROOM ETC.), AS PER OWNER'S SITE TEAM REQUIREMENT. TENTATIVE REQUIREMENT INDICATED IN THIS LAYOUT.
12. LOCATION OF VIEWING GALLERY ON TERRACE MAY CHANGE AS PER PROJECT LAYOUT AND SAME SHALL BE FINALISED DURING DETAILED ENGINEERING.
13. PROVISION OF LANDSCAPING AROUND CMCS BUILDING IS UNDER THE SCOPE OF BIDDER. APPROVAL OF CORRESPONDING WORKING DRAWING TO BE TAKEN FROM OWNER'S SITE EIC.
14. THIS DOCUMENT SHALL BE READ IN CONJUNCTION WITH TECHNICAL SPECIFICATIONS.
15. INDICATIVE ELEVATION OF MAIN GATE COMPLEX IS SHOWN. FURTHER DETAILING TO BE DONE AS PER TECHNICAL SPECIFICATIONS DURING DETAILED ENGG.
16. MINIMUM CEILING HEIGHT OF CMCS BUILDING SHOULD BE 4.5M.
17. PARKING AREA SHOWN FOR REPRESENTATION PURPOSE ONLY, MIN 3 EV CHARGING STATIONS AND AT LEAST 6 OPEN PARKING SPACES TO BE PROVIDED.
18. ALL THE FURNITURE AND FIXTURES ALONG WITH THE UTILITIES TO BE PROVIDED FOR PANTRY AND OTHER AREAS SHALL BE IN THE SCOPE OF BIDDER. FURTHER THE USABLES & TOILETRIES SHALL BE PROVIDED BY BIDDER DURING O&M PERIOD.

NTPC Limited

PROJECT NAME:	**EPC Package For Development of 12 MWac (14 MWp DC) ground-mounted Solar PV Plant integrated with a 6 MW / 12 MWh Battery Energy Storage System (BESS) at Seaqaqa, Vanua Levu, Fiji**
TITLE:	PLAN OF CENTRAL MONITORING CONTROL STATION (CMCS) BUILDING AND ELEVATION OF MAIN GATE COMPLEX

A

FOR TENDER PURPOSE ONLY

PREPARED BY	CHECKED BY		APPROVED BY	DATE	SIZE	SCALE	DRG. NO.	REV. NO.
SSS	CIVIL	ELE.	R.R. MAURYA	07.08.2026	A0	NTS	NTPC-0011-004-POC-A-006	R0
	RRM	HARIOM						

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