Tender No.

TNSO/LPG-E/LT-02/16-17

For

Providing roof top Solar Photo Voltaic Plants for generation of solar power at LPG Bottling Plants and POL Terminals in Tamil Nadu.

DUE ON 29.12.2016 AT 1500 HRS

TECHNICAL & COMMERCIAL BID

IndianOil Corporation Limited
(Marketing Division)
LPG DEPARTMENT
Indian Oil Bhavan
139, Nungambakkam High Road
Chennai - 400051
Tamil Nadu, India

E-Tender No. LPG/ENG/LT-02/16-17

E-Tender ID: 2016_SROTN_46051

for

Providing roof top Solar Photo Voltaic Plants for generation of solar power at LPG Bottling Plants and POL Terminals in Tamil Nadu.

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ANNEXURE - 1

NOTICE INVITING E-TENDER

Digitally signed and sealed (encrypted) E-Tenders are invited in Two-bid System (a) Part-I, Technical Bid with Commercial Terms and (b) Part-II, Price-Bid; for the work as detailed below:

1	**E-Tender No.**	**TNSO/LPG-E/LT-02/16-17**
	E-Tender ID	**2016_SROTN_46051**
2	**Name of Work**	Providing roof top Solar Photo Voltaic Plants for generation of solar power at LPG Bottling Plants and POL Terminals in Tamil Nadu.
3	**Earnest Money Deposit**	**Rs. 7,37,000/- (Rs. seven lakh thirty-seven thousand only).** In case of EMD submission by BG, the BG should be valid for 6 (six) months from the date of technical bid opening mentioned in this NIT.
4	**Download starts on**	15.12.2016
5	**Download closes on**	29.12.2016
6	**Due Date and time:**	
	a) Submission of tenders	29.12.2016 at 1500 HRS
	b) Opening of tenders (Technical Bid Only)	30.12.2016 at 1500 HRS
7	**Validity of tender**	**4 (Four) months** from date of technical bid opening mentioned in this NIT.
8	**Work Completion Time**	**4 (Four) Months**
9	**Contact Persons**	Manager (LPG Engg.), TNSO Tel.: (044) 28333783 Email: vvrao@indianoil.in

Tender documents have to be downloaded from our e-tender website https://iocletenders.gov.in .

Financial evaluation:

The tender shall be financially evaluated on overall lowest quoted amount in Price Bid (BoQ).

In case of more than one party having same quoted amount, the party with higher average annual turnover during **last 3 financial years ending 31.03.2016** shall be treated as the L-1 party. If annual turnover is not mentioned by tenderer for a particular year, it shall be considered as Zero for computing the average.

Award of Contract:

1. Location-wise contracts shall be awarded to respective L-1 Bidders.

2. In case any bidder has quoted L-1 rate for more than one location, he shall be awarded contract for all such locations subject to **max. 4 locations in serial order of BoQ**.

3. For balance locations where the same bidder is L-1, his quoted rates will be offered to L-2 bidder for matching. In case L-2 bidder refuses to match his quote with L-1 rates, the same will be offered to L-3 bidder and so on. The process will continue till such time L-1 rates are accepted by another bidder. In case no bidder agrees to match L-1 rates, these contracts will be awarded to L-1 bidder itself.

General:

Physical Bids will not be accepted. Tender Documents can be downloaded from https://iocletenders.gov.in and online bids are required to be submitted with Digital Signatures. All help files to upload the bids are available at https://iocletenders.gov.in website.

Off-line EMD and other documents as specified in the tender must be submitted to "**Deputy General Manager (LPG-Engg.), 5th Level, LPG Department, Indian Oil Corporation Limited, Marketing Division, Tamil Nadu State Office, 139 Nungambakkam High Road, Chennai- 600 034"** before due date and time of submission as mentioned above.

All intending bidders who view / download the tender document are advised to visit our website till the end date for any changes or addendums.

NSIC registered parties, Central/State PSUs and JVs of IOC are exempted from paying Earnest Money Deposit. However, the registration certificate issued by NSIC should be valid during tender consideration period and should cover items tendered while seeking exemption from payment of EMD.

The tenderers shall upload scanned copy of necessary documents as sought in tender documents / e-tender web portal.

Indian Oil Corporation reserves the right to accept / reject any or all tenders without assigning any reason whatsoever.

Tenders without valid EMD will be summarily rejected.

Notwithstanding any other condition/ provision in the tender documents, in case of ambiguity or incomplete documents, bidders shall be given only one opportunity with a fixed deadline after bid opening to provide complete & unambiguous documents meeting the requirement. In case the bidder fails to submit any document or submits incomplete document within the given time, the bidder's tender will be rejected.

ANNEXURE – 2

TECHNICAL / COMMERCIAL BID ABSTRACT
(TO BE FILLED BY THE TENDERER AND SUBMITTED)

SL. NO.	DETAILS	IOCL'S REQUIREMENT	PLEASE PROVIDE DETAILS AS REQUIRED
1.	**Earnest Money Deposit :**	**As per NIT**	
	a) Mode of EMD	Please mention mode of payment	
	b) Details of EMD Payment	Please mention details of EMD payment	
2.	a) Annual Turnover for last three Financial Years i.e. **FY 2013-14, FY 2014-15 & FY 2015-16**	Please confirm having uploaded copies of relevant pages from audited balance sheets and Profit & Loss Statements.	
	b) Proof of filing Income Tax Return for past three Assessment Years i.e. **AY 2014-15 AY 2015-16 & AY 2016-17**	Please confirm having uploaded acknowledgement copy of IT Returns.	
3.	Validity of tender	**4 months -** Please confirm acceptance.	
4.	Completion time	**4 months -** Please confirm acceptance.	
5.	Declaration A/B/C/D for relationship with Directors of IOCL properly filled up & submitted.	Please confirm having uploaded the details.	
6.	Holiday listing/ Black listing format filled up properly	Please confirm having uploaded the details.	
7.	Confirm that there are no deviations from tender conditions	Please confirm no deviation or with deviation (list to be provided for deviations).	
8.	Confirm that the scope of work and tender terms & conditions have been understood and agreed	Please confirm.	
9.	PF Registration number	Please provide PF registration number.	

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Scope of Work

EXISTING SYSTEM:

POWER SUPPLY DISTRIBUTION SYSTEM

All the existing feeders are fed through a 415 V LT bus which is being fed by Grid / Diesel Generators (in case of Grid outage).

SCOPE OF WORK:

PART A – SOLAR PV PLANT

Engineering, Procurement and Construction (EPC) of Grid Connected Captive Solar PV system on turnkey basis on the premises of LPG Bottling Plants and Oil Terminals in the State of Tamil Nadu and comprehensive O&M of the SPV plant for a period of **5 (five) years (1 year warranty period + 4 years AMC)** from the date of successful commissioning of the plant. The system shall be synchronized with Grid/DG (during grid outage) and shall also have net metering provision, if applicable.

It is, however, understood and confirmed by the Contractor that the scope as described in the tender document is not limiting in so far as the responsibilities of the Contractor shall include inter-alia, carrying out any and all works and providing any and all facilities those are required in accomplishing an operating system, complying fully with all requirements as are envisaged of it, complete in all respect and satisfying all performance and guarantee requirements stated or implied from the contents of the tender document. The work shall be executed in conformity with the relevant applicable latest standards, codes, rules/ordinances & regulations. The overall design & engineering of the plant shall be based on latest available technology and optimal usage of space to minimize losses and maximize efficiency.

The Contractor shall make all required liaisoning with all the agencies including all concerned power utilities for finalization/signing of Net Metering Agreement, if applicable, and other required approvals/permits/agreements so as to commence utilization of the power generated from solar power plant soon after its completion.

The detailed scope of work shall include but not limited to following :

PART A1 - SUPPLY

The equipment and materials for Solar PV Power Plant with associated system (typical) shall include but not be limited to the supply of the following:

a) Solar PV modules including mounting frames, fixed tilt structures, foundation bolts and nuts for holding structures.

b) DC junction boxes with string level monitoring and disconnection switches, distribution boxes and fuse boxes, MCBs, Surge Arrestors.

c) String Monitoring Unit/Box.

d) Power Conditioning Units, Remote Monitoring system, sensors, instrumentation.

e) Inverter Transformer, dry-type or oil filled as per the site conditions.

f) AC junction box/ACDB Box, in case multiple inverters are used.

g) Digital Voltage Meter and Ammeter, kWh meters, Ah (Ampere-hour) meters (in case of hybrid systems with battery), Metering instrument and protection relays along with battery system, ABT meters required for net metering scheme, if applicable.

h) Instrumentation and metering complying with the applicable grid code and specifications for operation and control of the plant. Appropriate instruments will be installed at suitable locations to measure the following details:

- Solar radiation/ Insolation Data
- Generation of Solar DC power measured at PCU/Inverter input as well as AC power fed from Solar PV System to the captive load bus
- Exported power (in case of net-metering, if applicable)
- Frequency
- Power Factor
- Energy export
- Grid power injection at captive load bus
- Individual DG power injection at captive load bus
- Battery energy (through Ah meters)

i) Batteries, in case of hybrid systems.

j) DC Cables, LT Power Cables, OFC and Control Cables including end gland terminations and other required accessories for both AC & DC power cables.

k) Cable trays.

l) Data acquisition system with remote monitoring facilities.

m) Lighting arrestors/ protection for the plant, tool kit and earthing kit.

n) Protection equipments, isolators, circuit breakers etc., if required.

o) PVC pipes, hume pipes and accessories/trenches, if required.

p) Earthing system for Switch Yard, Inverter room or inverters/PCUs, Module Mounting Structure, Lightning arrestor, Remote Monitoring system etc.

q) Fire extinguishers etc. as per requirement.

r) Security equipment such as IP night vision CCTV cameras, IR motion sensors etc.

s) Danger plates, name boards etc.

t) Mandatory spares.

u) Complete system for transmission of plant data to SLDC as per SLDC requirement, in case of net metering, if applicable.

v) Any other equipment/material required to complete the Solar Power Plant on turnkey Basis.

w) Special tools & tackles and test/measuring equipments

PART A2 – SERVICES

A. MOBILIZATION AT SITE

Storage facility for incoming material, arrangement of Power and Water requirement during project construction, Accommodation for the workforce required for construction.

B. CIVIL WORKS:

i) Excavation, Back filling, Stone pitching, shadow analysis etc., as required.

ii) All requisite foundations and structures wherever required (PV array foundation, outdoor switchyard equipments, etc.).

iii) Requisite conduiting, cable trenches for routing cables as required for the

a) PV array field
b) Inverter rooms / Inverters
c) Battery room
d) Remote monitoring system
e) Outdoor Switchyard, if applicable
f) Connection to captive load bus

iv) Arrangement of all requisite piping, valves & hoses for module washing water purpose and other services.

C. ENGINEERING DRAWINGS AND DATA:

The scope of the contractor includes complete design and engineering, technical coordination, finalization of drawings/ documents, submission of engineering drawing/ documents and processing for their approvals by the PMC/ Owner. Following documents in three copies each and a CD shall be submitted to Owner within 15 days of Award of Contract for review and reference:

i) Detail Technical Specifications, including Battery sizing (in case of hybrid system with battery)

ii) General arrangement drawing for the project and layout plan including

a) Single Line Diagram of the power plant

b) SPV Array Layout drawing

c) Switch gear – scheme of protection at captive load bus

iii) Quality Assurance Plans

iv) PERT diagram with critical path showing detailed time schedule of supply, erection and commissioning of the complete plant, including weekly level plans where applicable, and periodic review schedules (fortnightly or monthly). The entire work schedule should be subdivided into micro activity schedule interval with details of review plan.

Further, the scope shall also include submission, in proper shape & format, of all types of manuals, handbooks & documents in requisite numbers to the Owner at different phases of the project as per the requirement of Owner.

D. ALL STATUTORY CLEARANCES AND OTHER APPROVALS:

i) All statutory clearances related to electrical works required from the concerned State Power Utilities/ State Electricity Board/ Central Electricity Authority or any other statutory body shall be obtained by the Contractor, if required. Owner would fill up the required forms and applications as advised by the contractor.

ii) Arranging Chief Electrical Inspector General (CEIG) clearance/ permission to connect shall be in contractor's scope. The Contractor shall be responsible for interconnection of Solar PV power plant with the State grid and net metering agreement, if applicable.

iii) Capacity Registration with State Regulatory Agency, if required.

iv) For all the above clearances, the fees/ statutory charges shall be reimbursed by the Owner on production of receipt.

v) Tentative list of approvals and clearances that may be required are as below:

a) Connectivity approval for net-metering, if applicable

b) Project registration

c) Metering Approval, if applicable

d) Meter testing, CT, PT testing and inspection certificate

e) Clearance from Chief Electrical Inspector

f) Certificate of commissioning - Nodal Agency /Local Agency etc.

E. ELECTRICAL AND ELECTRONICS WORK:

i) Cable laying:

a) Laying of cables in cable trenches providing cable markers, including backfilling the trenches.

b) Making straight through joints using heat shrinkable sleeves for cables or as per applicable norms.

c) Connection, termination and testing of cables to distribution boards.

d) Proper sand bedding must be provided.

e) Wherever there is drainage or water flowing channels, the trenches should be water proof (i.e. brick lined/ RCC) and filled with sand to prevent any water accumulation or cables should be laid in GI/ hume pipes or wherever cable is passing through drain, rerouting of cables should be done.

ii) Earthing System:

Installation, testing and commissioning of earthing electrodes/ earthing strips as per the requirements mentioned in Technical Specifications Chapter.

iii) Telecommunication works (OFC/ Cabling works)

a) OFC/ Cable connectivity to enable remote access of SPV Plant data at Administrative Building of Plant. This includes provision of port in Remote Monitoring System, all internal OFC/ cabling from module arrays to PCUs to Remote Monitoring System (or otherwise), as applicable.

b) Supply, laying, termination and testing of cables & connectors, as per required specifications, drawing and appropriate standards.

c) Supply, erection and installation of indelible cable markers, including excavation and installation of Markers, cement concrete grouting, back filling etc. required as per drawing, specifications and directions of Site Engineer/ Engineer-In-Charge (EIC) including cost of all labour, tools & tackles, materials etc. complete in all respects.

d) Testing of all types of cables, including OFCs with their connectors installed with the plant as part of the work, after completing the laying work before commissioning of the plant system.

e) Remote Monitoring System to be provided with internet/ dongle facility for remote access.

F. TRANSPORTATION OF EQUIPMENT FROM WORKS TO SITE, STORAGE, AND ACCOMMODATION AT SITE

i) All necessary permits and licenses, as may be necessary, to transport the equipment/ material, machinery, and labour along or across highway, roadway, railway, bridge, dike, dam, river or through posts of toll collection, Octroi checks or other line border or barrier.

ii) C-forms/ Road permits if required to be issued by owner, would be provided by owner, the contractor to indicate the items for which C forms/ road permits would be required.

iii) Receipt, unloading & installation of all supplied equipment on foundations at their respective places.

iv) Proper storage of material before installation. Storage area shall be suitable to prevent equipment against rain & water logging.

v) Suitable accommodation & resting sheds for workforce.

G. QA/ QC

Submission of QA/QC procedure for all activities in line with the detailed work specification, relevant codes/standards of practice for approval of EIC before start of any work at site. The works shall be executed in line with the approved QA/ QC procedures.

H. TESTING

All acceptance and routine tests as per the specification, relevant standards and approved QAPs (Quality Assurance Plans) shall be carried out at the cost of the contractor. All the testing schedule for equipments/auxiliaries shall be intimated at least a week in advance. Third party inspection may be preferred as per the decision of owner. The decision for witnessing the test shall rest with IOCL. IOCL representative will decide to witness the type/ routine test as part of Factory Acceptance Tests (FATs) at the premises of manufacturer upon prior intimation of the test schedules.

I. PAINTING

Painting of all equipments and structures shall be done as per Owner's standard color coding scheme. The quality and finish of paints shall be as per standards of BIS or equivalent.

J. TRAINING OF OWNER'S PERSONNEL

Providing a detailed training plan on energy assessment, design, technologies, plant design, and erection & commissioning, operation & maintenance procedures, which shall, after approval by owner, form the basis of the training program. Contractor shall impart classroom as well as field training on site to owner personnel during works, erection, testing & commissioning of the plant and associated equipments.

Expenses towards travel, stay, lodging & boarding and other expenses for the owner's personnel shall be borne by the OWNER.

K. SYNCHRONIZATION, COMMISSIONING AND OPERATION

i) The Solar Power Project would be synchronized by the contractor to the local/ captive Grid System after taking proper approvals for net-metering facility, if applicable. It shall meet all the connection conditions prescribed in applicable Grid Code then in effect and otherwise meet all other Indian legal requirements for synchronization to the Grid System.

ii) In addition to above, contractor shall prepare and submit pre-commissioning and commissioning checklist in discussion with IOCL during construction and before commissioning of the plant.

iii) IOCL shall reserve the right to conduct Technical Audit of solar PV Power Plant after completion of commissioning.

L. PERFORMANCE GUARANTEE (PG) TEST

The performance guarantee tests shall be carried out as specified in SCC. All special equipment, tools and tackles, instruments, measuring devices required for the successful conductance of PG test shall be provided by the bidder, at his own cost. All costs associated with the PG tests shall be included in bid price.

M. CODES AND STANDARDS

i) The equipments and accessories covered shall be designed, manufactured and tested in accordance with the latest relevant standards and codes of practice published by the Bureau of Indian Standards (BIS), IEC, IS etc. as applicable. The quality of materials of construction and the workmanship of the finished products/components shall be in accordance with the highest standard and practices adopted for the equipment covered by the specification.

ii) All equipment shall be designed for operation in tropical humid climate at the required capacity in a minimum de-rating temperature of 50°C. Equipment shall be suitable for an ambient temperature of 50°C. Maximum relative humidity of 90% shall also be taken into consideration for design of equipment.

PART B – OPERATION & MAINTENANCE

The contractor shall perform comprehensive operation and maintenance (O&M) of the Solar Power Plant for a period of **1 (one) year** after establishment of successful commissioning of Solar PV Plant.

Thereafter, a separate O&M contract shall be entered into/ executed for the next **4 (Four) years**. O&M shall be carried out as detailed below.

OPERATION AND MAINTENANCE SPECIFICATIONS

Bidder shall be responsible for all the required activities for the successful running, optimum energy generation & maintenance of the plant, covering

i) Deputation of Engineering and supporting personnel

ii) Keeping the plant in operational mode so as to get optimum energy generation

iii) For hybrid systems with battery, regular maintenance of battery at periodic intervals

iv) Monitoring, controlling, trouble shooting, maintaining of records and registers

v) Supply of all spares, consumables and fixing/ application of the same

vi) Arranging equipments/instruments at his own cost as required from time to time for schedule and preventive maintenance, major overhauling of the project.

vii) Conducting periodical checking, testing, over hauling and preventive action

viii) Replacement of components/ equipments, if required

ix) General upkeep of all equipments, buildings, roads, etc.

x) Submission of daily/ periodical reports to Owner energy generation & operating conditions of the plant

xi) Continuous monitoring of performance of the plant during day hours and regular maintenance of the whole system including panels, transformers, overhead lines, outdoor kiosks, switchgear, equipments etc. for extracting and maintaining the maximum energy output from the plant

xii) Regular cleaning of the module surfaces

xiii) Continuous monitoring of plant performance through Remote Monitoring System

xiv) Frequent checking and calibration of instruments

xv) Developing a system of cross checking instrument indications with each other to determine whether the instrument is faulty or there is an abnormal operating condition

xvi) Developing a system of analyzing indicated data to determine accurately what could be wrong.

xvii) Monitoring and maintaining performance through operations & maintenance records

xviii) Coordination with various agencies, departments for continuous operation, maximum generation and energy certification

xix) Comply with applicable rules and regulations

xx) Operation and Maintenance of the plant including supply of spares and consumables from the date of commissioning of the project shall be carried out at fixed cost.

MAINTENANCE

After taking over the activity of O&M for the power plant, the Operator shall be responsible for the operation and maintenance of the plant and shall perform all necessary services including applicable services listed (in brief) below:

i) The bidder shall draw the preventive maintenance schedules and attend to the breakdowns keeping in view maximizing uptime and designed generation.

ii) Regular periodic checks shall be carried out as a part of routine preventive maintenance.

iii) Particular care shall be taken for outdoor equipment to prevent corrosion.

iv) Cleaning of the components/ equipments shall also be carried out at periodic intervals.

v) Resistance of the earthing system as well as individual earth pits are to be measured and recorded every month. If the earth resistance is high, suitable action is to be taken to bring down the same.

vi) The bidder shall keep at least one skilled and experienced supervisor at site on permanent basis to supervise the jobs that are being carried out at site.

vii) The Bidder will attend to any breakdown jobs immediately for repair/ replacement/ adjustments and complete at the earliest working round the clock.

viii) The Contractor shall immediately report the accidents, if any, to the Engineer-In-charge & to all the concerned authorities as per prevailing law of the State showing the circumstances under which it happened and the extent of damage and / or injury caused. O&M Contractor would be solely & fully responsible / liable to pay for any losses/damages/claims, etc. and Owner will be fully indemnified for such losses / claims.

ix) The Bidder shall immediately report the accidents, if any, to the Engineer-In-charge showing the circumstances under which it happened and the extent of damage and or injury caused.

x) The Bidder shall comply with the provisions of all relevant acts of Centre or State.

xi) Government Acts including payment of Wages Act 1936, Minimum Wages Act, 1948, Employer's Liability Act 1938, Workmen's Compensation Act 1923, Industrial Dispute Act 1947, Maturity Benefit Act 1961, Mines Act 1952, Employees State Insurance Act 1948, Contract Labour (Regulations & Abolishment) Act 1970 or any modification thereof or any other law relating whereto and rules made there under from time to time.

xii) The Contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.

xiii) The Contractor shall ensure that all safety measures are taken at the site to avoid accidents to his or his Co-Contractor's or Owner's Workmen.

xiv) If in the event of negligence or mal-operation by the Contractor's operator, any failure of equipment take place, then such equipment should be repaired / replaced by Contractor free of cost within a reasonable period of time.

xv) Establish robust preventive maintenance system to maximize up time and to ensure peak generation in peak periods

xvi) Careful logging of operation data/ historical information from the Data Monitoring Systems, and periodically processing it to determine abnormal or slowly deteriorating conditions.

xvii) Careful control and supervision of operating conditions.

xviii) Regulate routine maintenance work such as keeping equipment clean, preventive maintenance and checks of delicate ingredients of transformers, circuit breakers, junction boxes, module mismatches, Cleanliness of isolators also to be ensured.

xix) Repairs and replacements to ensure maximum uptime for the plant.

GENERAL O&M

i) To maintain accurate and up-to-date operating logs, records and monthly reports regarding Operation & Maintenance of the facility.

ii) To perform or contract for and oversee the Performance of periodic overhauls or maintenance required for the facility in accordance with the recommendations of the original equipment manufacturer.

iii) To maintain and up-keep equipment, power evacuation facilities etc. up to grid interconnection point, in workable conditions.

iv) To discharge obligations relating to retirement/ Superannuating benefits to employees (of the contractor) or any other benefit accruing to them in the nature of compensation, bonus in addition to salary, etc. for the period of service with the Contractor.

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SPECIAL CONDITION OF CONTRACT (SCC)

Contents

1. GENERAL

1.1. Special Conditions of Contract (SCC) shall be read in conjunction with the General Conditions of Contract (GCC), Job Specifications, drawings and any other document forming part of this contract, wherever the context so requires.

1.2. Notwithstanding the sub-division of the documents into these separate parts and volumes, every part of each shall be deemed to be supplementary to and complementary of every other part and shall be read with and into the contract in so far as it may be practicable to do so.

1.3. Where any portion of the GCC is repugnant to or at variance with any provision of the SCC, then the provision of the SCC shall be deemed to override the provisions of the GCC and shall, to the extent of such repugnance or variations, prevail.

1.4. Wherever it is mentioned in the specifications that the Contractor shall perform certain works or provide certain facilities, it is understood that the Contractor shall do so at his own cost, being deemed to be part of the relevant item in the SCHEDULE OF RATES / BOQ (SOR) whether expressly stated or not.

1.5. The materials, design and workmanship shall satisfy the relevant Indian Standards, the specifications contained herein and codes referred to. Where the specifications stipulate requirements in addition to those contained in the standard codes and specifications, these additional requirements shall also be satisfied.

1.6. In so far as the contract does not deal with or provide by expression or implication for any aspect or specification with respect to the product(s) or any of them or with respect to any other matter or thing required to be furnished, done or supplied relative thereto or for the delivery thereof according to the contract, the internationally accepted relevant specification, standard of workmanship and/ or codes or practices, as the case may be, shall apply. In the event of any doubt or ambiguity relative thereto, the Contractor shall seek the clarification of IOCL.

2. DEFINITIONS

The following expressions hereunder and elsewhere in the Contract documents used and their grammatical variations shall unless repugnant to the subject or context thereof, have the following meanings hereunder respectively assigned to them, namely:

2.1. **"Bidder / Tenderer"** shall mean the company, who has submitted their bid individually, against this tender document to Indian Oil Corporation Ltd. (IOCL) and includes the Bidders' legal representative, his successors and permitted assignors.

2.2. **"BOQ"** shall mean Bill of Quantities.

2.3. **"Contractor"** means any person, company, firm or body who may be engaged by the Owner for works and services connected with the Project.

2.4. **"Engineer In-charge (EIC)"** shall mean Engineer responsible for the execution of the work of Solar PV Power Project.

2.5. **"GCC"** shall mean General Conditions of Contract.

2.6. **"Owner"** shall mean Indian Oil Corporation Limited.

2.7. **"PGT"** shall mean Performance Guarantee Test.

2.8. **"PMC"** shall mean Project Management Consultant.

2.9. **"SCC"** shall mean Special Conditions of Contract.

2.10. "**SOR**" shall mean Schedule of Rates.

3. BRIEF SCOPE OF WORK

IOCL intends to appoint suitable contractor with adequate credentials, through tender for development of Solar Photovoltaic Project at IOCL's premises on turnkey basis at LPG Bottling Plants and Oil Terminals in the State of Tamil Nadu. The brief Scope of Work shall be as mentioned hereinafter but not limited to the following:

3.1. **Part-A** - Engineering, Procurement and Construction (EPC): Design, Engineering, Manufacturing, Supply, Packing and Forwarding, Transportation, Unloading, Storage, Installation, testing and Commissioning of Solar Photovoltaic Project for captive consumption and comprehensive Operation & Maintenance of the plant for a period of one year from the date of successful project commissioning.

3.2. **Part-B** - Operation and maintenance: Operation and maintenance of plant for a period of 4 year from the date of completion of work mentioned in Part A.

4. SITE DETAILS

The site addresses are given below :

Sl. No.	Location Name & Address	Contact Person
1.	**Madurai LPG Bottling Plant:** Indian Oil Corporation Ltd., Madurai LPG Bottling Plant, Kalladipatti Post, Ammanayakannur via, Dindigul Dist. PIN - 624 201	Shri V. Nagarajan, CPM Cell: +91 9443389136
2.	**Chengalpet LPG Bottling Plant:** Indian Oil Corporation Ltd., Chengalpet LPG Bottling Plant, Paddalam PO, Kolambakkam Village, 16th KM from Chengalpat on NH-45,	Shri Murali D., CPM Cell: +91 9444065837

	Maduranthakam Taluk, Kancheepuram Dist. PIN- 603308	
3.	**Trichy LPG Bottling Plant:** Indian Oil Corporation Ltd., Trichy LPG Bottling Plant, Imankulathur, Tiruchirapalli Dist., Trichy- 621 303	Shri Govindan Ravi, CPM Cell: +91 9444401218
4.	**Erode LPG Bottling Plant:** Indian Oil Corporation Ltd., Erode LPG Bottling Plant, Sipcot Complex, Perunthurai, Erode Dist. PIN- ,- 638 052	Shri P. Jayaprakash, DGM (P) Cell: +91 9463501000
5.	**Ennore LPG Bottling Plant:** Indian Oil Corporation Ltd., Ennore LPG Bottling Plant, 143, Athipattu Village, NCTPS Main Road, Chennai- 600 120	Shri J. Sivakumar, DGM (P) Cell: +91 9445194153
6.	**Sankari POL Terminal:** Indian Oil Corporation Ltd., Sankari Terminal, Narappan Chavadi, Sankari Durg RS, Salem Dist.- 637302	Shri Prabhakar Kumar, CTM Cell: +91 9442613017
7.	**Trichy POL Terminal:** Indian Oil Corporation Ltd., Trychy Terminal, 191, SIDCO Women Industrail Estate, Vazhavanthankottai, Trichy- 620 015	Shri H.J. Manshani, CTM Cell: +91 9443149119
8.	**Tuticorin POL Terminal:** Indian Oil Corporation Ltd., Tuticorin Terminal, Tuticorin	Shri S. Vanjicko, CTM Cell: +91 9444910932
9.	**Madurai POL Terminal :** Indian Oil Corporation Ltd., Madurai Terminal, SIDCO Industrial Estate, Kappalur, Madurai- 625 008	Shri Renganathan V., CTM Cell: +91 9444085653
10.	**Coimbatore POL Terminal :** Indian Oil Corporation Ltd., Coimbatore Terminal, Athappa Gounden Pudur (Hamlet), Irugur, Coimbatore - 641 103	Shri P.Radjaradjane, CTM Cell: +91 9443056080

11.	**Korukkupet POL Terminal :** Indian Oil Corporation Ltd., Korukkupet Terminal, Kathivakkam High Road, Korukkupet, Chennai - 600 021	Shri Seetharaman S, DGM (T) Cell: +91 9444062924

5. EXISTING ELECTRICAL SYSTEM AT PLANT

All the existing feeders are fed through a 415 V LT bus which is being fed by Grid / Diesel Generators (in case of Grid outage).

6. CONTRACTOR SUPPLIED MATERIAL

6.1. All the equipments, materials, field instruments, consumables, etc. which are not specifically indicated in Owner's Scope of Supply but are required for successful completion of the works as per specification, drawing, construction methodology etc., shall be included in the Contractor's Scope of Supply.

6.2. All materials required for the civil works including cement, reinforcement, structural steel, sheeting, consumables, testing appliances, tools and tackles necessary for completing the work shall be supplied by the contractor at his own cost and shall conform to the job specifications and SCHEDULE OF RATES/ BOQ. No claim/ delay on this account will be entertained by the Owner.

6.3. The Contractor shall ensure that only the qualified and experienced subcontractor(s) are appointed by him for discharge of work or part thereof. The Contractor may appoint sub-contractors for various works from IOCL approved vendors / subcontractors for certain materials / services. For other vendors / subcontractors contractor may seek approval of EIC.

6.4. All expenses towards mobilization at site and demobilization including bringing in equipment, work force, materials, dismantling the equipment, clearing the site after completion of work and liaisoning with the State Grid and other concerned departments, if required, etc. shall be deemed to be included in the prices quoted and no separate payments on account of such expenses shall be entertained.

6.5. Contractor may have to work in energized or partly energized conditions. In such cases, it shall be the responsibility of the Contractor to arrange for necessary permits or shut downs and provide skilled and responsible persons for the execution of works. Contractor shall organize his works during the shutdown periods properly and complete the programmed works within the time given. Contractor shall not be paid any extra payments for working under the above said circumstances.

6.6. It shall be entirely the Contractor's responsibility to provide, operate and maintain all necessary construction equipments, scaffoldings and safety gadgets, cranes and other lifting tackles, tools and appliances to perform the work in a workman like and efficient

manner and complete all the jobs as per time schedules. However, if any equipment/ facility are provided by Owner, the same shall be on chargeable basis.

6.7. Procurement and supply, in sequence and at the appropriate time, of all materials and consumables shall be entirely the Contractor's responsibility and his rates for execution of work will be inclusive of supply of all these items.

6.8. In case any material is issued by the Owner, then it will be properly used and maintained. Subsequent to completion of its use, it will be returned to Owner in good condition. In case of damage or misuse of such stores, Owner will recover the cost from the Contractor from the payments due to the Contractor.

6.9. ***All bought out items shall have approval of Third Party Inspection Agency appointed by the contractor considering any one of the reputed agencies viz.*** **M/s PDIL, M/s CEIL, M/s Bureau Veritas, M/s IRS, M/s Lloyds, M/s TUV and M/s DET Norske Veritas**.

7. TIME SCHEDULE

7.1. Time schedule for completion of entire work upto commissioning of the full capacity of Solar Photovoltaic Panels at each location will be **4 (four) months** from the date of Letter of Acceptance (LOA). Work on all the locations awarded to the successful bidder has to start simultaneously for which adequate manpower and infrastructure must be mobilised by the contractor. The date of commissioning shall be considered as defined separately in SCC.

7.2. Performance Guarantee Test within 3 months from the date of commissioning.

7.3. Free Operation & Maintenance (O&M) of Solar plant shall be for 12 months from the date of commissioning.

7.4. Overall completion time for work mentioned in clause 3.2 of SCC is 48 months from date of completion of clause 3.1 of SCC.

7.5. The contractor shall submit a detailed PERT chart in line with the proposed time schedule covering all activities with various key phases of supply and service obligations under the contract such as supply schedule and field erection activities within fifteen (15) days of the date of LOA.

7.6. The time of commissioning / acceptance shall be inclusive of time for mobilisation, engineering, approval of the design & other materials and intervening monsoon, if any.

8. WORK SCHEDULE

8.1. Upon award of work, the Contractor shall provide detailed work schedule to the Engineer-In-Charge (EIC) covering all activities related to supply, installation, testing and commissioning falling under the scope of work.

8.2. There would be a kick-off meeting with the contractor, where in the contractor would present the detailed action plan, work plan schedule, critical/ long delivery item plan, etc. along with the fortnightly review schedule.

9. GUARANTEES

9.1. Security Deposit

9.1.1. In partial modification of Clause 2.1.0.0 & Clause 4.4.0.0 of the General Conditions of Contract, the Contractor shall within 15 days from the date of issue of the LOA, furnish Security Deposit for an amount equivalent to **10% of the work order value** in the form of Bank Guarantee (BG) towards Contract Performance Guarantee (PG) for commissioning of the full capacity of the project, establishment of PGT and for performance of 1 year free O&M.

9.1.2. The above BG towards Security Deposit cum Performance Guarantee shall be valid in the first instance for a period of not less than **19 months** from date of LOA.

9.1.3. If the total value of the Guarantee amount becomes deficient at any time till commissioning of project, the Contractor shall make up the deficiency within 10 (ten) days of such occurrence, by furnishing a BG for the deficient amount, failing which, the Owner shall be entitled to make up the deficiency by adjustment recovery from the Running Bills or any other amount payable.

9.1.4. For the Operations & Maintenance (O&M) contract period the BG (**1% of the total quoted price for Part-A**) shall be furnished before the start of the O&M Period. The BG towards Security Deposit for O&M shall be valid in the first instance for a period of not less than **15 (fifteen) months**. The Bank Guarantee shall be renewed every year during the O&M period.

9.1.5. BG shall be submitted by the Contractor as per format given in GCC from any scheduled bank in India or any foreign bank operating in India under the rules of Reserve Bank of India.

9.1.6. BG shall be returned to the Contractor after the validity is over and all the obligations of the contractor under the contract have been met.

9.1.7. If the completion of work of Part-A is delayed beyond schedule or there is short-fall in performance of Part-B, the owner will recover the price discount as described separately in SCC from pending bills, if any, else through encashment of BG submitted by the Contractor.

9.2. Defect Liability Period

In partial modification to clause 5.4.1.0 of GCC, the defect liability period for the works (including the materials incorporated therein within the Contractor’s scope of supply) shall be 12 (twelve) months from the date of project commissioning as defined in PROJECT COMMISSIONING & ACCEPTANCE Clause.

9.3. **Manufacturer’s warranty**

9.3.1. The manufacturer's warranty for all bought out items shall be made available to the Owner and shall be valid for the entire defect liability period. However, this does not absolve the Contractor of his responsibilities under defect liability clause to perform in attending to the defects noticed and rectifying these without any delay.

9.3.2. Manufacturer's/Contractor’s warranty, for any replaced item shall also be made available to the Owner and shall be kept valid for the original warranty period.

9.3.3. Guaranteed performance data as required in the specifications shall be included as part of the contract. The Contractor shall furnish further, such data and this shall form a part of the contract document.

9.3.4. The Contractor shall warrant that the goods supplied will be new and in accordance with the Contract Documents and be free from defects in material and workmanship. The Contractor shall further warrant that the Goods supplied under this contract shall have no defects arising from design, material or workmanship or from any act or omission of the Contractor, which may develop under normal use of the supplied goods in conditions obtaining in the country of final destination.

9.3.5. The Contractor shall replace/ repair to the satisfaction of the Owner any defective parts in the Goods of his own manufacture or those of his subcontractor’s under normal use and arising solely from faulty design, materials and/or workmanship.

9.3.6. If it becomes necessary for the Contractor to replace or renew any defective equipment/ component/ part/ material of the Solar PV Plant (during the warranty period), the provision of this Clause shall apply to items so replaced or renewed until the expiration of defect liability period/warranty period, whichever is greater. If any defects are not remedied within thirty (30) days from the date of notice by the Owner, Owner may proceed to do the work at the Contractor’s risk and cost, but without prejudice to any other rights, which the Owner may have against the Contractor in respect of such defects.

9.3.7. The repaired or new parts will be furnished and erected free of cost by the Contractor. If any repair is carried out on his behalf at the Site, the Contractor shall bear the cost of such repairs.

9.3.8. The cost of any special or general overhaul rendered necessary during the maintenance period due to defects in the plant or defective work carried out by the Contractor, the same shall be borne by the Contractor.

9.3.9. The acceptance of the Goods by the Owner shall in no way relieve the Contractor of his obligation under this clause.

9.3.10. Timely replacement/ repair of the defective part would be at contractor’s cost.

9.3.11. At the end of the warranty Period, the Contractor's liability ceases except for latent defects.

9.3.12. The inverters/ PCUs and Battery (in case of hybrid systems with battery) shall be warranted for **5 years** from date of commissioning.

9.3.13. All photovoltaic modules should carry a linear performance warranty from second year. The solar PV modules offered should not degrade more than 2.5% for first year and not more than 0.7% from second year of its rated power. During the first 10 years and entire life span of 25 years the solar modules should not degrade more than 10% and 20% of its rated power respectively.

9.4. **Performance Guarantee Test (PGT)**

9.4.1. Solar PV System

Initiation of PGT to establish quality of Solar PV System installed shall be upon prior intimation to EIC.

The performance of the solar PV system installed shall be established through Performance Ratio (PR) test as described in **Annexure-A (Performance Evaluation)** of this chapter. To establish successful PGT, minimum 75% of PR shall be established. In case of failure to establish the PGT during first test period, the contractor may initiate the next test period for establishing the PGT upon prior intimation to EIC. The contractor shall have to establish the successful PGT of installed system within 3 months from the date of commissioning.

9.5. **Yearly Performance Evaluation**

9.5.1. Solar PV System

Yearly Performance Evaluation shall be done in the last month of every year (as described in Annexure-A of this chapter) during execution of free O&M of Part-A as well as during the execution of Part-B of the contract as described in Clause 3 of SCC.

10. SCHEDULE OF RATES / BOQ

10.1. All the items of work mentioned in the SCHEDULE OF RATES / BOQ and covered by the Contract shall be carried out as per the drawings, specifications and under the direction of EIC and shall include all costs/ expenses including equipment, labour, logistics, transport, travel & stay arrangements, attending meetings, presentations at IOCL office, collection of necessary data, other incidentals including supply of materials, etc. as may be necessary for rendering the services in totality as per detailed technical specifications of the Tender. The Contractor shall be and remain at all-time exclusively responsible to provide all material, consumables, labour supervision, equipment tools machines, permits, licenses, casements and facilities and other items and things whatsoever required for or in connection with the work, included but not limited to those indicated by expression or implication in the SCHEDULE OF RATES/ BOQ, Technical

Specification, approved designs, plans, drawings and/or other Contract documents or howsoever otherwise required either for incorporation within the permanent works or in relative to the execution and performance of the work. The format for schedule of rate can be found in Part II.

10.2. The rates stated in the SCHEDULE OF RATES / BOQ shall not be subject to escalation or increase on any account whatsoever, other than new taxes, duties, levies etc. imposed by Central or State Government subsequent to submission of the bid.

10.3. Complete contents of the Price Bid / SOR shall be made available in the un-priced offer with the words "Quoted" (but not the actual prices) at the places wherever prices are there in the priced part of offer. If the price quote is made in the un-priced offer, the bid shall be liable for rejection.

10.4. The Bidder shall quote prices for the total services.

10.5. The breakdown of materials pertains to supply of major items. It will be the responsibility of the bidder to supply all materials/ Equipments required for completion of work as per contract, irrespective of whether all items are identified in Schedule of Rates / BOQ.

10.6. **TOTAL for PART-A & PART-B taken together i.e. supply of Plant and Equipment including Mandatory spares of schedule of rates shall not exceed 75% (Seventy five percent) of TOTAL price of schedule of rates.**

In case the quoted price of L-1 bidder for Part-A & Part-B taken together exceeds 75% of total quoted price, IOCL will place WO on L-1 bidder after bringing down his quoted price for Part-A & Part-B to 75% of total quoted price. The bidder is bound to accept the same otherwise it will be treated as non-acceptance of contract and his EMD will be forfeited apart from other punitive action as per tender terms & condition including putting the bidder on holiday list.

11. TERMS OF PAYMENT

IOCL shall pay the Contractor in the following manner and at the following times, on the basis of the Price Breakdown given in the Section on Price Schedules. Application for payment in respect of part deliveries may be made by the Contractor as work proceed.

11.1. **PART A: SUPPLY OF SOLAR PV PLANT**

% of contract price of SOR / BOQ item Part A	Milestone
Seventy Percent (70%)	On receipt and physical inspection of equipment at site on pro-rata basis for the equipment received and stored at site.
Ten percent (10 %)	On successful Project Commissioning.
Ten percent (10%)	On successful completion of PGT.

Ten percent (10%)	Shall be paid during 12 months free O&M period on pro-rata basis at the end of every quarter in four equal instalments, provided PGT has been successfully established. The payment for last quarter (2.5%) shall be done upon establishment of Yearly Performance Evaluation Test in the last month of free O&M period (i.e. 12th month from commissioning) and Completion Certificate issued by the EIC.

PART B : SUPPLY OF MANDATORY SPARES

% of contract price of SOR / BOQ item Part B	Milestone
Eighty percent (80%)	On receipt and physical inspection at site on pro-rata basis for the equipment/spares received and stored at site.
Twenty percent (20%)	On successful Project Commissioning.

PART C : INSTALLATION AND COMMISSIONING SERVICES FOR SOLAR PV PLANT

% of contract price of SOR / BOQ item Part C	Milestone
Seventy Percent (70%)	On completion of installation of equipments on certification by the EIC for the quantum of work completed.
Ten Percent (10%)	On successful Project Commissioning.
Ten Percent (10%)	On successful completion of PGT.
Ten percent (10%)	Shall be paid during 12 months free O&M period on pro-rata basis at the end of every quarter in four equal instalments, provided PGT has been successfully established. The payment for last quarter (2.5%) shall be done upon establishment of Yearly Performance Evaluation Test in the last month of free O&M period (i.e. 12th month from commissioning) and Completion Certificate issued by the EIC.

PART D : POST WARRANTY ANNUAL MAINTENANCE

i) Quarterly payment of 25% of the yearly contracted value as per Part-D of SOR will be released upon EIC's concurrence for satisfactory performance of O&M activity as per the O&M checklist, duly approved by EIC at the start of O&M activity, and production of the following documents:

- Record of faulty components/ sub-systems, if any, repaired or replaced during the quarter.
- Record of O&M carried out by the Contractor during the quarter as per schedule approved by EIC/Owner representative.
- A certificate for compliance to the existing laws for employment of the manpower, and payments for statutory taxes and duties

ii) Each stage of payment as indicated here-in-above shall be applicable only when the work has been accepted in accordance with the contract specification up to that particular stage.

iii) The payment against supply of equipment/ material at site will be made by the Owner only after obtaining an undertaking from the Contractor that such equipment and materials will be incorporated for the works covered under this contract and will not be taken out without Owner's prior permission. The contractor has to hypothecate all these equipments/ materials to the owner and keep them as issued items to him to for erection and construction of the plant.

iv) All payments will be made in Indian Rupees only.

v) Payment shall be released through e-banking only.

vi) The payment of O&M charges shall be made on quarterly basis after deduction of leviable taxes and adjustment of dues payable to owner. The owner will be billed by the Contractor/ Operator promptly following the end of each quarter of O&M period.

vii) The O&M charges shall be quoted with applicable taxes & duties showing separately. Any increase in statutory taxes, levies / fees or newly imposed taxes would be charged extra (with submission of documentary proof). Similarly, due credit would be reimbursed/ passed on to Owner in case of withdrawal or reduction in applicable taxes/ fees/ duties.

12. CONDITION OF WORK SPECIFIC REQUIREMENTS

12.1. **Civil works**

12.1.1. The contractors must note that relevant codes shall be made available at site for reference whenever demanded.

12.1.2. Contractors must note that sufficient provision of shuttering materials is made available at Site including implements and equipment.

12.2. **Electrical works**

12.2.1. Code Requirements:

The electrical works shall comply with all applicable statutory regulations comprising of but not limited to the following: -

i) Indian Electricity Rules 1956, Electricity act 2003, Grid Code

ii) General Conditions of Power supply of State Electricity Boards, RLDC, and SLDC

iii) Tariff Advisory Committee, CERC, SERC

iv) Any other statutory Body/ Authority

12.2.2. Statutory Clearances

The contractor has to obtain all the clearances as per clause of Scope of Work.

12.2.3. Commissioning/operation

The contractor shall provide labour & equipments/ machinery for testing and commissioning of the entire system.

The Contractor at his own cost and without delay to suit the commissioning programme shall carry out rectification of defect in any work done by the Contractor.

12.2.4. Electrical Inspector’s Approval/ Completion/ Acceptance/ Performance Test/ Third Party Verification

The contractor shall produce license secured from State Electricity Board to the EIC for verification, wherever required. Contractors have to perform the job with qualified personnel recognized by the Electricity Board inspectorate. For this purpose, contractor shall furnish the details pertaining to supervisory competence certificate and wiremen license of concerned workers for carrying out electrical works as they will be actually engaged in the daily execution of the job. On completion of electrical installation, the contractor shall furnish the completion certificate to the Electrical Inspectorate, if required. The certificate shall be prescribed in the form as required by the local inspectorate, if required. The Contractor shall approach the Inspectorate and arrange for inspection, seek approval in writing before starting up of the testing work and also before commissioning the installation. However, the necessary fee paid to Inspectorate shall be reimbursed by the Owner on submission of actual receipts.

12.3. **Standardisation**

Installation methods and procedure for equipment supplied by the contractor shall conform to standard design and shall be uniform. Particularly for cable jointing, fixing labels, cable gauging and supports, termination etc. so that installations are uniform in appearance.

12.4. **Workmanship (General)**

Electrical equipment shall be installed and electrical work undertaken by qualified and competent tradesman/ supervisors. Manufacturer's installation instruction and recommendations shall be closely followed at all times. Particular care shall be taken

with transformers, switchgears and other equipment to ensure that the metal joints are clean and that safe gaps are not exceeded. Adequate weather protection during installation shall be provided at all times.

13. TEST, INSPECTION AND PERFORMANCE OF WORKS

13.1. The Contractor shall carry out the routine tests as enumerated in the relevant standards/codes, technical specifications and approved Quality Assurance Plans (QAPs) for respective components/ systems and no separate payment shall be made unless otherwise stipulated. The type test certificates shall be submitted at the time of Factory Acceptance Tests (FATs). In case, any type test is scheduled during the period of delivery of the component, the same shall be intimated to Owner for its witness at factory premises.

13.2. All the tests either on the field or at outside laboratories concerning the execution of the work and supply of materials by the Contractor shall be carried out by Contractor at his own cost. All test equipment including all recording/ measuring gauges/ instruments shall be calibrated and necessary certificate of compliance issued by the Statutory agency/body to the effect that the test equipment's /instruments have been calibrated as per standard practices and found meeting the norms shall have to be furnished by the Contractor. The entire cost of carrying out such calibration and furnishing of the compliance certificate from a Statutory Authority/ body shall be at the expense of the Contractor.

13.3. The work is subject to inspection at all times by the Owner/ EIC. The Contractor shall carry out all instructions given during inspection and shall ensure that the work is being carried out according to the technical specifications, the technical documents and the relevant codes of practice furnished to him during the performance for the work. Contractor shall discuss his daily work programme with Site Engineer/ EIC before starting the same every day.

13.4. Any work not conforming to the execution drawings, specifications or codes shall be rejected forthwith and the Contractor shall carry out the rectification at his own cost.

13.5. All results of inspection and tests will be recorded in the inspection reports, performa of which will be approved by the EIC. These reports shall form part of the completion documents.

13.6. In addition to the provisions of clause 5.2.0.0 of GCC, on no account shall the Contractor proceed with the backfilling or other underground works by covering up or otherwise placing beyond reach of inspection or measurement before inspection by the Site Engineer or his authorised representative. Should the Contractor do so, the same shall be uncovered at Contractor's risk and expense for carrying out the inspection and measurement.

14. SETTING OUT OF THE WORKS

14.1. The Contractor shall be responsible for the true and proper setting out of the works and for the correctness of the position and levels, dimension and alignment of all parts of the works and for the provision of all necessary instruments, appliances and labour in connection therewith.

14.2. If at any time during the progress of the work, shall any error appear or arise in the position, level, dimension or alignment of any part of the works, the Contractor shall at his own expense rectify such error to the satisfaction of EIC or the Site Engineer.

14.3. The checking of any setting-out or of any line or level by the EIC or the Site Engineer shall not in any way relieve the Contractor of his responsibility for the correctness thereof and the Contractor shall carefully protect and preserve all bench marks, pegs and other things used in setting out the works.

15. WATER & POWER SUPPLY

15.1. In partial modification of the provisions of clause 3.4.0.0, 3.5.0.0 & sub clauses thereof of the GCC, the contractor shall arrange construction water/ procure water required for the work at his own cost. Owner shall not be responsible for supplying water and Contractor shall ensure timely and adequate supply of water to meet the schedule.

15.2. During EPC stage, the contractor will make his own arrangement for power required for the work at his cost. Owner shall not be responsible for power supply and contractor shall ensure proper supply of electricity to meet the schedule.

15.3. The electrical works shall be carried out through licensed electrical personnel only.

16. PERSONAL ACTS & LIABILITIES

Any money paid to any director, attorney, agent, officer or employee of the Contractor and any receipt, settlement, acknowledgement of liability or other arrangement, agreement or document whatsoever signed by any such director, attorney, agent, officer, or employee of the Contractor or erstwhile director, attorney, agent, officer or employee of the Contractor (without notice of his cessation of interest) or by any person held out to be a director, attorney, agent, officer or employee of the Contractor authorized to act on behalf of and/or to bind the Contractor, shall be binding upon the Contractor and shall constitute a full release and discharge to the Owner and/or settlement, acknowledgement or obligation of, upon or with the Contractor, as the case may be , and the Owner shall not be concerned with the actual application of any money so paid or of the actual authority of such director, attorney, agent, officer or employee (actual, erstwhile or purported as the case may be) vis-à-vis the company to make the settlement, receipt, acknowledgement, agreement or other document concerned.

17. PATENT INDEMNIFICATION

Further to General Conditions of Contract clause no. 8.10.0.0, Contractor shall indemnify the Owner against all losses, costs, damages and expenses arising from any claim asserted against Owner that the work or part thereof, or any methods, designs or

things furnished or specified by Contractor or any sub-contractor or supplier under this Contract, or any use thereof in the reasonable contemplation of the parties at the time furnished, or any methods, processes or acts employed by Contractor in connection with the performance of its obligations hereunder constitutes an infringement of any patent, trade secret, proprietary information, know-how copyright (statutory or non-statutory), un-patented invention or any unauthorized use of the work of others.

18. RESTRICTION OF VISITORS

The Contractor shall not allow any visitors on the work or premises of the site without the approval of EIC and/ or site engineer.

19. SAFETY AND POLLUTION CONTROL

In addition to the provisions of clause 10.0.0.0 of GCC, the Contractor shall take all reasonable precautions to avoid pollution or contamination of the air, land or water arising out of the performance of the work. Disposal of returns and cuttings produced by the work shall not be allowed to be discharged in the river. Contractor shall make arrangement at his own cost and initiatives to dispose of the return and cuttings generated from the drilling operation, as to avoid any pollution to the environment. Should there be a discharge or escape of appreciable quantity of pollutants or contaminants during performance of its obligations under this contract which occurs as a result of activities of the Contractor or its sub-contractor, the Contractor shall immediately take all necessary actions to contain, control, recover or disperse the substance and to eliminate the safety and environmental risks and correct the damages resulting there from.

19.1. Adherence to safety procedures and practices

Contractor shall ensure that the prudent industrial safety measure, applicable to the plant as per the norms and statutory requirements are adhered to during the EPC as well as O&M phase. In case of accidents depending on the seriousness of injury etc. in addition to the hospitalisation/ treatment charges and group insurance amount, compensation shall be paid by the Contractor to the affected person/ his family members in presence of EIC as per Workmen Compensation Act.

19.2. Safety practices while working at height

Contractor shall ensure that the prudent safety measure, applicable to the plant as per the norms and statutory requirements are adhered to during the EPC as well as O&M phase.

20. NO COMPENSATION FOR ALTERATION IN OR RESTRICTION OF WORK

If at any time from the commencement of the work, the Owner shall for any reason whatsoever not require the whole work or part thereof as specified in the tender to be carried out or, alteration in the work are required, the EIC shall give notice in writing of the fact to the Contractor, who shall have no claim to any payment or compensation

whatsoever on account of any profit or advantage which he might have derived from the execution of the work in full or prior to alteration.

21. CONTRACTOR'S OFFICE AT SITE

21.1. During the execution of the contract, the Contractor shall ensure responsible person with authority to take decisions to be available at site. Such person deputed by the Contractor shall report to EIC for smooth execution and timely completion of the work. The Contractor shall also provide and maintain an office at the site for the accommodation of the agents and the staffs and such office shall be open at all reasonable hours to receive instructions, notices or other communications. The Contractor shall be responsible for any misconduct/ indiscipline by his employees or sub-Contractor/ agent employee's. The Contractor shall abide by the instructions of the EIC, if given in this regard. The office must equipped with

- Storage space
- Seating arrangements for contractor and Owner's representative
- Wash room

21.2. EPC Contractor shall submit the Manpower Chart with hierarchy that would be deployed at site.

22. SUB-CONTRACTING OF WORK

Contractor shall not subcontract or assign, in whole or in part, its obligations to perform under this contract, except with Owner's prior written consent. In the eventuality of sub-contracting of work, Owner will be informed in advance. However, the Contractor's liability or obligations will not get altered/delegated to sub-contractor. If any sub-contractor engaged upon the work at the site executes any work which in the opinion of the EIC is not in accordance with the contract documents, the Owner may give written notice to the Contractor advising him to terminate such sub-contracts and the Contractor on the receipt of such notice shall terminate such contracts.

23. POWER OF ENTRY

23.1. In case the Contractor does not commence the work in the manner described in the contract documents or if he shall at any time in the opinion of the EIC:

a) Fail to carry on the works in conformity with contract document/ schedule, or

b) Substantially suspend work or the works for a continuous period of 14 days without permission from the EIC, or

c) Commit or permit any other breach of any of the provisions of the contract on his part to be performed, or

d) Abandons the works, or

e) During the continuance of the contract becomes bankrupt.

23.2. In any such events, the Owner shall have the power to enter upon the works and take possession of the materials, temporary works, equipment, tools and stocks thereon, and to revoke the Contractor's order to complete the works by his agents, other Contractors or workmen.

24. USE OF COMPLETED PORTIONS

24.1. Whenever in the opinion of the Owner, the work or any part thereof is in a condition suitable for use and in the best interest of the Owner requires use, the Owner may take possession of the same. The Contractor shall, however, be not relieved of his pending obligations.

24.2. Prior to the date of final acceptance of the work by the Owner, all necessary repairs or renewals in the work or part thereof so used on account of defective materials or workmanship or due to the operations failure shall be at the expenses of the Contractor. Such use shall neither relieve the Contractor or any of his responsibilities under the contract, nor act as waiver by the Owner of the conditions thereof. However, if in the opinion of the Owner, the use of the work or the part thereof delays the completion of the remainder of the work, the Owner may grant such extensions of time as it may consider reasonable. The decision of the Owner in the matter shall be final. The Contractor shall not be entitled to claim any compensation on account of such use by the Owner.

25. POWER OF THE ENGINEER-IN-CHARGE (EIC) TO ORDER SUSPENSION OF WORK

The EIC may, from time to time by direction in writing and without invalidating the contract, order the Contractor to suspend the work or any part thereof at such time or times and for such reasons as he may consider necessary. After such directions to suspend the work or any part thereof have been given, Contractor cannot then proceed with the work or part thereof, directed to be suspended, until he receives a written order from the EIC to proceed. In the event of suspension, the Owner may under the provisions of the contract, extend the time for completion of the work or part thereof by such period as it may find reasonable. The decision of the Owner in the matter shall be final and binding on the Contractor.

26. DEFECTS PRIOR TO TAKING OVER

26.1. If at any time before the work is taken over, EIC shall:

a) Decide that any work done or materials used by the Contractor or any sub-contractor is defective or not in accordance with the contract, or that the works or any portion thereof, are defective, or do not fulfil the requirements of contract (all such matters being hereinafter, called Defects in this Clause).

AND

b) As soon as reasonably practicable notice given to the Contractor in writing of the said decision specifying particulars of the defects alleged to exist or to have occurred, then the Contractor at his own expense and with all efforts shall make good the defects so specified.

26.2. In case the Contractor fails to do so, the Owner may take, at the cost and risk of the Contractor, such steps as in all circumstances be reasonable to make good such defects. The expenditure so incurred by the Owner will be recovered from the amount due to the Contractor. The decision of the EIC with regard to the amount to be recovered from the Contractor will be final and binding on the Contractor. As soon as the works have been completed in accordance with the contract and have passed the tests on completion, the EIC shall issue a certificate in which he shall certify the date on which the works have been so completed and have passed the said tests and the Owner shall be deemed to have taken over the works on the date so certified.

27. DEFECTS AFTER TAKING OVER

27.1. In order that the Contractor could obtain a completion certificate, he shall rectify any defect arising from the defective materials supplied by the Contractor or workmanship or any act or omission of the contract or that may have been noticed or developed after the works or group of the works has been taken over, the period allowed for carrying out such works will be normally 15 days. Normally it is expected that work will be completed within 15 Days. However in case of unforeseen /genuine delay, EIC may take a call on this aspect whose decision will be final. If any defect be not remedied within period stipulated above, the Owner may proceed to do the work at Contractors risk and expense and deduct from the final bill such amount as may be decided by the Owner/EIC.

27.2. If by reason of any default on the part of the Contractor, a completion certificate has not been issued in respect of the works within one month after the date fixed by the Contractor for the completion of the work, the Owner shall be at liberty to use the works or any portion thereof in respect of which a completion certificate has not been issued, provided that the works or the portion thereof so used as aforesaid shall be afforded reasonable opportunity for completion of these works for the issue of completion certificate.

27.3. All the aforesaid safeguards/ rights provided for the Owner shall not prejudice its other rights/ remedies elsewhere provided herein and/ or under law.

28. PROJECT COMISSIONING AND ACCEPTANCE

Project Commissioning:

Project commissioning shall be established when the entire plant capacity is synchronized to the captive load bus and net-metering facility/ license established, wherever applicable.

Project Acceptance:

The Contractor shall submit Acceptance Report of the project to Owner after completion of Part A of the scope of work **except** for the one year comprehensive free O&M period. The Report shall consist of the following documents:

a) Successful PG test (as prescribed in Clause 10.4 of this chapter) completion report.

b) Technical documents as per scope of work & technical specifications according to which the work has been carried out including but not limited to following;

   i) Four sets of as built drawings showing therein modification and corrections, if any, made during the course of execution signed by the Contractor. A soft copy of as built drawings shall also be submitted (CAD, PDF and any other format as required).

   ii) Copy of complete layout of the solar array including power injection layout/ system.

   iii) Copies of test certificates for type/routine tests performed on major equipment.

   iv) O&M Manuals – 4 sets

   v) Copies of Statutory clearances / permissions.

   vi) Certificate/undertaking for making payment of all statutory requirements, duties, labour wages and others for having made payment.

   vii) An undertaking confirming the payment of all statutory duties, taxes or document(s) having evidence of paying statutory duties, taxes etc. as per requirement of concerned statutory authorities.

   viii) Certificate regarding completion of the facility in all respect by the EIC.

   ix) List of all mandatory spares which are duly tagged and stored.

Take over shall occur after the successful completion of Performance Guarantee Test (PGT) of the system (Solar PV system and Battery system, in case of hybrid systems with battery) and issuance of Final Acceptance certificate and, if and only if:

   i) A Performance Test Report has been prepared by the Contractor and accepted by the Owner in accordance with the Contract,

   ii) All Permits required to operate and maintain the Plant have been obtained,

   iii) The Contractor has completed all the Scope of Work related to EPC works,

   iv) The Contractor has obtained the Commissioning Certificate for the Solar Plant,

   v) All sub-contractors have been paid the dues by the Contractor and no-dues certificates received from such sub-contractor,

   vi) All statutory or legal liabilities on account of the work performed under the contract have been duly calculated and paid by the Contractor,

   vii) All as-built drawings have been submitted to the Owner,

viii) Detailed Engineering document with detailed specification, schematic drawing, circuit drawing and test results, manuals for all deliverable items, Operation, Maintenance & Safety Instruction Manual and other information about the project have been submitted to the Owner.

Owner shall issue Acceptance Certificate after verifying from the documents and satisfying itself that the work has been completed in accordance with details set out in the construction and erection drawings and the contract documents. No Certificate shall be given nor shall the work be deemed to have been executed until the feeding of generated Solar power commenced to captive load bus, statutory requirements are completed if net-metering is applicable, and all scaffolding, surplus materials and rubbish is cleaned off the site completely.

29. COMPLETION CERTIFICATE

Owner shall issue Completion Certificate after satisfying itself that the work has been completed in accordance with details set out in the contract documents. No Completion Certificate shall be given nor shall the work be deemed to have been executed until the following are ensured:

a) Contractor submits the Acceptance Report of the project.

b) All Owner's property and documents handed over to EIC.

c) And, fulfilment of all the requirement of PROJECT COMISSIONING AND ACCEPTANCE.

30. STATUTORY APPROVALS FOR WORKS

30.1. Statutory and other related approvals

The clearances/ approvals in respect of installation, testing and commissioning of the complete electrical and associated system would be obtained by contractor on behalf of the owner. Owner would fill up the required forms and applications under the advice of the contractor for clearance from/for:

a) State Power Utilities, if required

b) State Renewable Energy Development Agency, if required

c) Chief Electrical inspectorate General (CEIG)

30.2. Contractor shall obtain other statutory approvals/ clearances, if and wherever required, from government departments but not limited to the following:

a) State renewable energy development agency

b) Pollution control board of the state

c) Other applicable permissions/ clearances relevant for the offered site

30.3. The Contractor shall ensure facilitation of net-metering provision, if applicable, through necessary liaisoning and coordination with state regulatory authorities within the time schedule as described in Clause 8 of this Chapter.

30.4. The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.

30.5. The contractor shall ensure that all safety measures are taken at the site to avoid accidents to his or his Co-contractor's or Sub-contractor's or Owner's Workmen.

30.6. Repair/ replace any equipment/ part/ components/ systems in time in the event of failure/ breakdown which is not on account of natural calamity or of the force majeure events etc.

31. PROGRESS REPORT & PROJECT REVIEW MEETING

31.1. The contractor shall submit fortnightly and monthly progress report (soft and hard copies) along with catch up plans against slippages to EIC/ Owner.

31.2. Owner shall hold project review meetings with Contractor at pre-defined periodicity defined at the onset of project, during project kick-off meeting.

32. OBLIGATIONS PRIOR TO TAKING OVER OF THE O&M ACTIVITY

The Operator shall perform the following obligations prior to taking over of the O&M activity:

a) Submit Performance Bank Guarantee for the O&M period as stipulated.

b) Prepare Mobilization plan in consultation with the Owner

c) Provide the services and personnel set forth in the Mobilization Plan

d) Prepare in consultation with the Owner/EIC, the initial Annual Operating Plan

e) Develop and implement plans and procedures including those for fire fighting, maintenance planning, procuring and inventory control of stores and spares, plan to meet emergencies, plant safety and security, and such other facilities and systems as may be necessary to commence O&M Operator's ongoing responsibilities.

33. HANDING OVER THE PLANT AFTER EXPIRY OF TERM

33.1. After the expiry of term & extension of term as the case may be, operator shall hand over the plant to the owner in excellent condition. The operator shall demonstrate performance test of all the major & critical equipment to ensure Generation from the Solar Photovoltaic Power Plant. While handing over the plant, operator shall hand over all technical documents, literature, instruction manuals, lists of spare part & tools & tackles, and mandatory spares should be duly tagged and stored. Operator shall also hand over all the relevant record/documents, spares and consumables in new condition as handed over at the start of contract.

33.2. On completion of O&M term, the Operator will apply to the EIC for the issue of Handing Over Certificate and the same will be issued within 1 months of the Handing Over in all respects, after verifying from the documents & tests and satisfying that the Operation & Maintenance has been completed in accordance with details set out in the control documents & Prudent Utility Practices.

33.3. All the aforesaid safeguards/ rights provided for IOCL shall not prejudice its other rights/ remedies elsewhere provided herein and/ or under law.

34. DEFECTS/ NON-ACHIEVEMENT PLANT DEPENDABLE CAPACITY AFTER HANDING OVER

34.1. In order for the Operator to obtain a Handing Over certificate, he shall rectify any defect/ non-achievement of plant dependable capacity in accordance to the norms of manufacturer arising from the defective Operation & Maintenance practices or noncompliance of Prudent Utility Practices or that may have been noticed or developed during/after the plant has been taken over, the period allowed for carrying out such works will be normally one month. If any defect could not be remedied or plant dependable achievement capacity in accordance to the norms of manufacturer could not be achieved within a reasonable time, the Owner may proceed to do the work at operator's risk & expense and deduct from the final bill such amount as may be decided by the Owner.

34.2. All the aforesaid safeguards/rights provided for the Owner shall not prejudice its other rights/ remedies elsewhere provided herein and/ or under law.

35. PRICE DISCOUNT

35.1. **Price discount for delay in project commissioning**

It is contractor's responsibility to complete all the work and avail all the approvals on time.

In case contractor is unable to commission the project on time, the price discount would be at the rate of **1% of entire contract value per week of delay, subject to maximum of 10% of the total contract value.**

35.2. **Price Discount for non-achievement of required performance ratio/capacity establishment for battery (in case of hybrid systems with battery) during PGT**

The price discount applicable at the end of Performance Guarantee Test for the guaranteed minimum performance ratio of 75% and 100% of designed battery capacity upon tests shall be as follows:

Should the actual performance ratio for the Plant be less than the guaranteed 75% **or** should the actual established capacity of battery be less than 100% of approved designed battery capacity at PGT, the owner shall have the right to claim from the Contractor: 2% of the total contract amount for each percentage point of reduction of – (i) the Plant's actual measured output below the Guaranteed Performance, **or** (ii) the actual capacity of approved designed battery capacity, on pro rata basis. The evaluation of Performance Guarantee Test for Solar PV system shall be as per Annexure-A to this chapter and for Battery system shall be as per Annexure-**B** to this chapter.

35.3. **Price Discount for non-achievement of required performance ratio/capacity establishment for battery (in case of hybrid systems with battery) during Free Operation & Maintenance of Part-A (Clause 3 of this Chapter)**

If the actual performance ratio for the plant is less than the guaranteed performance in Yearly Performance Evaluation Test during the free O&M period as described in Annexure-A to this chapter **or** if the actual battery capacity is less than the guaranteed capacity in Yearly Performance Evaluation Test during the free O&M period as described in Annexure-B to this chapter, the owner shall have the right to claim price discount at the rate of 10% of the 4-year average O&M contract value quoted for the Part-B as described in Clause 3.2 of the SCC, for reduction of each % of reduced PR **or** battery capacity against set guaranteed value on pro-rata basis.

The evaluation of Yearly Performance Evaluation for Solar PV system is as per **Annexure – A** of this chapter and for Battery system is as per Annexure-B of this chapter.

35.4. **Price Discount for non-achievement of required performance ratio/capacity establishment for battery (in case of hybrid systems with battery) during Operation & Maintenance as described in Part-B of Clause 3.2**

If the actual performance ratio for the plant is less than the guaranteed performance in Yearly Performance Evaluation Test as described in the Annexure-A of this chapter **or** if the actual battery capacity is less than the guaranteed capacity in Yearly Performance Evaluation Test as described in the Annexure-B of this chapter, the owner shall have the right to claim price discount at the rate of 10% of the O&M contract value of the year for reduction of each % of reduced PR **or** battery capacity against set benchmark value on pro rata basis.

The evaluation of Yearly Performance Evaluation for Solar PV system is as per **Annexure – A** of this chapter and for Battery system is as per Annexure-B of this chapter.

ANNEXURE – A

PERFORMANCE GUARANTEE TEST / YEARLY PERFORMANCE EVALUATION

(FOR SOLAR PV SYSTEM)

"Performance Ratio (PR)" is defined as below:

$$\textit{Performance Ratio (PR) of a plant for a period of time} = \frac{\textit{Energy generated (kWh)}}{\textit{Irradiance (kWh/m}^2\textit{) x Active area of PV module (m}^2\textit{) x PV module efficiency}}$$

The Performance Guarantee Test (PGT) will be performed upon fulfilment of conditions given in Clause 2 of this Annexure and will include tests described under Clause 3 of this Annexure.

The Yearly Performance Evaluation Test shall be done in the last month of every year during execution of free O&M of Part-A as well as during the execution of Part-B of the contract as described in Clause 3 of SCC. The Yearly Performance Evaluation Test shall include tests described under Clause 3 of this Annexure.

1. DEFINITIONS

1.1 H_t – 1-minute integrated total irradiation (in kWh/m^2) measured at the plane of modules by 1 no. Class-II integrating pyranometer installed

1.2 J_t – 1-minute average irradiation (in W/m^2) measured at the plane of modules by 1 no. Class-II integrating pyranometer installed

1.3 $E_{GEN,t}$ – **Net electric energy (DC) generated** from solar system (in kWh) during each 1-minute interval measured at the Inverter/PCU input by integrated/separate multi-function energy meter installed

1.4 P_N – Total installed PV capacity (W_p), where P_N varies as below during the PGT/various Yearly Performance Evaluation Tests as per the deration value of the Solar PV Modules as specified in Clause 3.1 of Technical Specifications in Job Specifications chapter:

	Value of P_N
For PGT : **P_0**	Total installed capacity of Solar PV Modules (in W_p)
For Yearly Performance Evaluation Test during Free O&M as per Part-A of Clause 3.1 of SCC : **P_1**	97.5% of **P_0**
For Yearly Performance Evaluation Test during 1st year of O&M as per Part-B of Clause 3.2 of SCC : **P_2**	96.8% of **P_0**
For Yearly Performance Evaluation Test during 2nd year of O&M as per Part-B of Clause 3.2 of SCC : **P_3**	96.1% of **P_0**
For Yearly Performance Evaluation Test during 3rd year of O&M as per Part-B of Clause 3.2 of SCC : **P_4**	95.4% of **P_0**

For Yearly Performance Evaluation Test during 4th year of O&M as per Part-B of Clause 3.2 of SCC : **P_5**	94.7% of **P_0**

1.5 G_{STC} – Standard irradiance i.e. 1000W/m^2

1.6 R_t –Percentage regulation value as recorded by controller of Solar Grid DG Management System every 1-minute

Where, subscript 't' used above is the count of 1-minute interval for recording of average/net values of parameters defined above. There will be such 4320 nos. of 1-minute intervals (1440 intervals in a day x 3 days) during the Performance Test Period (PTP), i.e. t ranges from 1 to 4320.

2. CONDITIONS TO PROCEED WITH PGT

The PGT will be executed after fulfilment of following conditions:

1.1 Commissioning of the entire PV Plant shall be achieved.

1.2 The Monitoring System shall be completely installed and under operation with all the sensors calibrated.

1.3 The Contractor shall undertake to submit all the technical documentation requested by IOCL as mentioned in the sections of tender document.

1.4 Only qualified personnel from the Contractor or personnel from other companies appointed by the Contractor, with suitable skill in electrical equipments, measurement shall be allowed to perform the prescribed inspections.

1.5 Before inspection, the area subject to inspection has to be cleaned and any installation that could hinder any functional tests shall be removed.

1.6 The 1-minute duration, t, as defined in Clause 1 should be same for 1.1, 1.2, 1.3 and 1.6 and the recorded parameters by different measuring instruments as described in the respective clauses shall be available through single data logger having time stamping facility.

3. PROCEDURE AND CALCULATION

The PGT/Yearly Performance Evaluation Test shall be carried out during a **3-day** period (referred to as **the Performance Test Period – PTP**).

Total Reference Energy during PTP shall be calculated through the formula:

$$E_{Ref} = \frac{P_N}{G_{STC}} \text{x} \sum_{t=1}^{4320} H_t$$

For calculation purposes, when J_t < 100 W/m^2 or R_t < 100%, H_t shall be taken as zero, i.e. such values of H_t shall be rejected (not considered in above summation).

Total Energy Generated from solar during PTP shall be calculated through the formula:

$$E_{GEN} = \sum_{t=1}^{4320} E_{GEN,\,t}$$

For calculation purposes, when J_t < 100 W/m^2 or R_t < 100%, $E_{GEN,t}$ shall be taken as zero, i.e. such values of $E_{GEN,t}$ shall be rejected (not considered in above summation).

There should be at least 1440 nos. of non-zero readings of E_{Ref} and E_{GEN} considering the above mentioned condition on availability of J_t & R_t. If the required numbers of readings are not available, then the duration of PGT shall be extended beyond 3-days to have at least 1440 nos. of non-zero readings of E_{Ref} and E_{GEN}.

The **Performance Ratio** during PTP shall be calculated through the formula:

In order to consider the Performance Guarantee Test positively passed, the following condition must be satisfied:

$$PR \geq 75\%$$

In order to consider the Yearly Performance Evaluation Test positively passed, the following condition must be satisfied:

$$PR \geq 75\% \text{ or PR last established during PGT/Yearly Performance Evaluation, whichever is low.}$$

Energy losses attributable to following events shall not be considered for performance guarantee evaluation:

- Shut-downs caused by factors not controlled by the Contractor or it's subcontractors
- Force Majeure
- Vandalism or theft.
- Modifications at the site or its surroundings due to factors out of control of the Contractor (i.e. shadowing due to new installations on the site or next to the site, etc).

ANNEXURE-B

PERFORMANCE GUARANTEE TEST / YEARLY PERFORMANCE EVALUATION

(FOR BATTERY SYSTEM)

The Performance Guarantee Test (PGT) will be performed upon fulfilment of conditions given in Clause 1 of this Annexure and will include tests described under Clause 2 of this Annexure.

The Yearly Performance Evaluation Test shall be done in the last month of every year during execution of free O&M of Part-A as well as during the execution of Part-B of the contract as described in Clause 3 of SCC. The Yearly Performance Evaluation Test shall include tests described under Clause 2 of this Annexure.

1. CONDITIONS TO PROCEED WITH PGT

The PGT will be executed after fulfilment of following conditions:

1.1 Commissioning of the entire PV Plant shall be achieved.

1.2 All the batteries are connected as per approved drawings.

1.3 The Monitoring System shall be completely installed and under operation with all the sensors calibrated.

1.4 The Contractor shall undertake to submit all the technical documentation requested by IOCL as mentioned in the sections of tender document.

1.5 Only qualified personnel from the Contractor or personnel from other companies appointed by the Contractor, with suitable skill in electrical equipments, measurement shall be allowed to perform the prescribed inspections.

2. PROCEDURE

The Contractor shall adhere to IEEE 450 (IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-Acid Batteries for Stationary Applications) or IEEE 1188 (IEEE Recommended Practice for Maintenance, Testing and Replacement of Valve-Regulated Lead-Acid Batteries for Stationary Applications) for conducting the tests for establishment of Battery capacity, as per the type of battery selected. A brief methodology to conduct the test is given in following clauses; however the procedure outlined in the latest version of IEEE standards shall overrule.

2.1 HIGH RATE DISCHARGE TEST AT SPECIFIED DC AS PER THE DUTY CYCLE TILL END OF DISCHARGE VOLTAGE OF CELL AS PER SPECIFICATION (**TO BE PERFORMED AT PGT**)

2.1.1. Readings of all cells for temperature, specific gravity and voltage shall be taken before high rate discharging.

2.1.2. Since constant high current discharge is to be done where the output voltage of battery will vary from maximum to minimum, therefore check should be done for the variation of resistance of the load bank suitable for this range.

2.1.3. Adjust the resistance during the discharge for maintaining value of current for specified times.

2.1.4. Confirm that the battery terminal voltage is not less than the specified value at the end of discharge at the rated discharge current. Necessary temperature correction as per the IS specification should be applied to arrive at the battery capacity. The battery capacity shall not be less than the specified AH capacity at duty cycle high rate discharge, up to an end cell voltage as specified by the manufacturers approved specification at 27^0C. Also during the above discharge test, individual cell voltage should not be less than volts per cell as specified by the manufacturers approved specification at 27^0C.

2.2 RECHARGING OF THE BATTERY FOLLOWING HIGH RATE DISCHARGE (**TO BE PERFORMED AT PGT**)

2.2.1. Readings of all cells for temperature, specific gravity and voltage shall be taken before charging.
2.2.2. Switch on the switches connecting the battery to the battery charger.
2.2.3. Recharge the battery immediately after discharge by limiting the constant current in between the specified range given by the manufacturers instruction manual.
2.2.4. Keep a format ready for recording battery terminal voltage, specific gravity and the temperature of the electrolyte of all pilot cells at an hourly basis.
2.2.5. The current should be reduced to the finishing rate once the cell voltage reaches 2.36 volts per cell. Continue the charging at this rate till the voltage reaches to 2.7/2.75 volts per cell. Confirm the charging duration from manufacturers specification. At the end of recharge, the specific gravity of the cells and voltage of each cell should be constant for 3 consecutive readings.
2.2.6. Record the readings in the format, for all cells at the end of charge.

2.3 C10 CAPACITY DISCHARGE AND IMPEDANCE TEST AT SPECIFIED DISCHARGE CURRENT (**TO BE PERFORMED AT YEARLY PERFORMANCE EVALUATION TEST**)

2.3.1. Record the specific gravity, voltage & temperature of each cell prior to discharge test.
2.3.2. Since constant current discharge is to be done for C10 discharge where the output voltage of battery will vary from maximum to minimum, check should be done for the variation of resistance of the load bank suitable for this range.
2.3.3. Also, ensure that the shunt and the ammeter in the DCDB is checked and confirmed for being calibrated.
2.3.4. Isolate the battery circuit from the DCDB bus by putting the isolator switch off. Keep the battery charger switch off. Now connect the load bank to the battery test terminals. Measure the resistance as seen into the load bank terminals. This value should be commensurate with battery bank initial terminal voltage and the C10 discharge current.
2.3.5. Keep a format ready to note the battery bank voltage, pilot cell voltage, electrolyte specific gravity and temperature immediately after 6 minute from switching on the load, subsequently after every hour and every 5 min during final stages/hour of discharge. Also note down bank voltage.
2.3.6. Put the load bank on. The discharge of battery starts. Keep noting the values as per the format mentioned in 2.1.5.
2.3.7. Keep adjusting the resistance continuously to maintain a constant discharge current during the discharge period.

2.3.8. Confirm that the battery terminal voltage is not less than the specified value at the end of discharge at the rated discharge current. Necessary temperature correction as per the IS specification should be applied to arrive at the battery capacity. The battery capacity shall not be less than the specified AH capacity at C10 discharge rate to an end cell voltage as per manufacturers instruction manual at 27^0C. Also during the above discharge test, individual cell voltage should not be less than specified as per manufacturer's instruction manual.

2.3.9. At the end of discharge period, switch off the load bank connection.

2.3.10. The impedance value of the cell shall not be less than 80% of the manufacturer's prescribed value.

2.4 CHARGE THE BATTERY FOLLOWING C10 DISCHARGE (**TO BE PERFORMED AT YEARLY PERFORMANCE EVALUATION TEST**)

2.4.1. Readings of all cells for temperature, specific gravity and voltage shall be taken before charging.

2.4.2. Switch on the switches connecting the battery to the battery charger.

2.4.3. Recharge the battery immediately after discharge by limiting the constant current in between the specified range given by the manufacturers instruction manual.

2.4.4. Keep a format ready for recording battery terminal voltage, specific gravity and the temperature of the electrolyte of all pilot cells at an hourly basis.

2.4.5. The current should be reduced to the finishing rate once the cell voltage reaches 2.36 volts per cell. Continue the charging at this rate till the voltage reaches to 2.7/2.75 volts per cell. Confirm the charging duration from manufacturers specification. At the end of recharge, the specific gravity of the cells and voltage of each cell should be constant for 3 consecutive readings.

2.4.6. Record the readings in the format, for all cells at the end of charge.

2.4.7. Keep the battery charger in float condition.

2.5 BATTERY RECHARGING BEFORE TAKING INTO SERVICE (**TO BE PERFORMED AT PGT AND YEARLY PERFORMANCE EVALUATION TEST**)

2.5.1. Charge the battery bank at specified constant current, till the cell voltage reaches 2.7/2.75 volts.

2.5.2. Give a rest period of 1 or 2 hours and recharge the battery at current rate of 20% of the rated 10-hour capacity of the battery bank for the duration specified by the manufacturer (which is approximately 8 hours). This is almost equivalent to equalize charge, therefore the charger should be put on equalize mode.

2.5.3. The temperature corrected specific gravity of the cells should be maintained at 1.200±0.005 at 27^0C for all cells.

2.6 TAKING BATTERY INTO SERVICE

2.6.1. The test result should be scrutinized and the battery shall be taken over by the site.

2.6.2. All terminal connectors shall be once again checked for tightness.

2.6.3. Petroleum jelly shall be applied over all terminals.

2.6.4. Electrolyte level should be adjusted to MAX line.

2.6.5. All battery stands shall be checked.

2.6.6. All the surfaces wherever paint has peeled off shall be touched up with a suitable paint.

2.6.7. Keep the battery charged in float mode.

3. ACCEPTANCE CRITERIA

3.1.1. All cells shall be found to be in healthy condition with no internal short circuit, i.e. the output voltage per cell shall be available for all cells after all the testing.

3.1.2. At PGT, test results should be as per the specifications and manufacturers recommendations. Battery should give C10 rating specified and high rate duty cycle discharge specified as per the specifications and manufacturers recommendations.

3.1.3. At PGT and yearly performance evaluation, battery shall be deemed acceptable upon establishment of following battery capacities:

	Battery Ah Capacity
During PGT: C_0	100% of approved design capacity
Yearly Performance Evaluation Test	
During Free O&M as per Part-A of Clause 3.1 of SCC: C_1	97% of C_0
During 1st year of O&M as per Part-B of Clause 3.2 of SCC: C_2	97% of C_1
During 2nd year of O&M as per Part-B of Clause 3.2 of SCC: C_3	97% of C_2
During 3rd year of O&M as per Part-B of Clause 3.2 of SCC: C_4	97% of C_3
During 4th year of O&M as per Part-B of Clause 3.2 of SCC: C_5	97% of C_4

ANNEXURE-C

LIST OF MAJOR TAGGED ITEMS

1. Solar PV Modules
2. PCUs/Inverters
3. Battery, if applicable
4. Inverter Transformer(s)
5. DC & AC Cable
6. AC Switchgear

Technical Specifications

1.0.SYSTEM DESCRIPTION:

1.1. Solar Photovoltaic (SPV) grid connect/ hybrid (grid + solar + diesel generators) system shall consist of minimum following items:

i) Solar PV Modules

ii) Module Mounting Structures

iii) String Monitoring Box(s)/ Unit(s)

iv) Grid Interactive MPPT Solar String Inverters/ Central Inverters/ Hybrid Inverters with input DC Energy measurement

v) Inverter Transformer(s) (Dry type), built-in-Inverter or in an enclosure close to each String Inverter unit/ Central Inverter

vi) ACDB with manual rotary bypass changeover

vii) AC LT Breaker Feeder/ AC Switchgear

viii) Earthing Kit

ix) Lightning Arrester

x) Battery (for system with power storage)

xi) Solar Grid DG Management System

xii) Remote monitoring system (Microprocessor based Data Logger or any equivalent system)

xiii) Flexible & armored Cables (AC and DC), Cable Trays and other Hardware accessories

xiv) Multi-function Energy Meters (1S Class) and Ampere Hour Meters as applicable

xv) ABT meter as per the specifications prescribed by state electricity regulatory authorities, in case net-metering is permissible

1.2. All items in appropriate quantity shall be ensured to complete the project while ensuring quality as stipulated in the industry standards.

1.3. The 3Ø-output of the system shall be fed to the AC switchgear breaker feeder (included in the scope of this tender) which shall be synchronized further with the existing AC switchgear bus to cater loads already connected i.e. solar power shall be synchronized with the captive load/ grid supply. In case, the net-metering facility is presently not available, facility must be available in the PCU/ Inverter such that the excess AC power generated through Solar PV System should not get exported to the Grid automatically through suitable electronic controls by reducing the power generation technique and not by interrupting the Inverter operation.

1.4. It shall be ensured that solar power generation and utilization is maximized. The balance power requirement shall be met from other sources i.e. Grid or Diesel Generator (DG). PCU shall take reference voltage from either of the source available (Grid/ Diesel Generator).

There should be no break in the supply while changing from one mode to another mode of operation, in case of hybrid system.

1.5. It shall be ensured that Diesel Generators are never run below their minimum operating load condition. The PCU circuit must ensure that it synchronizes with DG set automatically and even if the load has reduced on the load bus, no harm is done to DG set and whole system continues to work.

1.6. Solar Grid DG Management System shall be provided. The system shall have following features –

i) Linear control of solar output (0-100%)

ii) Suitable for monitoring solar hybrid system (including battery, if included in the scope) vs. grid power injection at captive load bus

iii) Suitable for preventing flow of power to grid on all the days, and should allow the power flow to grid if net-metering is available or is made available in future.

iv) Suitable for monitoring controller regulation

v) Suitable for operating with different/ multiple inverter make

vi) SMS and e-mail alert feature for daily generation and failure

1.7. String Monitoring Box(s)/Unit(s) (SMB(s)/SMU(s)) shall be provided in between solar array and PCU. It shall have DC disconnector and fuses of suitable rating for connection and disconnection of array section. Type II Surge Arrestor should be incorporated for surge protection. There should be a provision for measurement and display of SPV string voltage and current. Appropriate IP protection (IP65 for outdoor and IP32 or better for indoor) shall be provided. In case of string inverter(s), if the requirements served by SMB(s) are fully taken care by multiple inverter(s), then the proposal (if any) for elimination of SMB(s) from the system design, can be considered.

1.8. There should be a provision in the system for monitoring of operating parameters such as string voltage/ current, inverter input/ output voltage and current, kW, kWh, battery Ah, kVAr etc. and also system diagnostic alarms, if any, at a centralized location. It shall have an integrated/ separate energy meter, ampere hour meter, voltmeter and ammeter. As for energy, generally the parameter of interest shall be the aggregate DC energy input to inverter(s) fed into the Inverter(s)/ PCU(s) and net energy exported in case where net metering/ gross metering is permissible. Class II Surge Arrestors should be incorporated for protection against any surges, wherever required.

1.9. Communicable multi-function energy meter (Class 1S) and ampere hour meter (in case of systems with battery) with RS-485 communicable port shall be provided for solar power system at its breaker panel as well as individually with each of the DG breaker panel under operation at the location.

If non-communicable electro-mechanical type energy meters are available at Grid breaker panel, the same shall have to be replaced with Communicable multi-function energy meter (Class 1S) with RS-485 port.

1.10. All breakers available for Solar (or hybrid solar system with battery), Grid and DGs shall have NONC control contacts through which suitable wiring/cabling can be done from respective breakers to the Controller/Solar Grid DG Management System.

1.11. The overall PV system should comply with the minimum technical requirements/ standards for SPV systems specified in MNRE release.

2.0. GENERAL REQUIREMENTS:

2.1. SPV modules shall be installed on shade free area. The corresponding Inverter(s) and distribution boards etc. shall be housed suitably.

2.2. Array structure of PV yard and all electrical equipments such as PCU/ inverters, transformers, batteries (if available) etc. shall be grounded properly.

Four separate earthing system shall be provided, each for DC Circuits, AC Circuits, Electronic Circuits and Lightning Protection System (LPS). If the inverters to be installed require separate earthing as per OEM recommendations, the same needs to be provided.

Towards this end, adequate number and appropriate size IS:3043 compliant earthing pits suitably calculated as per the design criterion or at least one each for AC circuit, DC circuit, Electronic circuit and lightning protection system, whichever is more shall be ensured. The complete earthing job including preparation of earthing pits and connection with the existing earth grid, if any, shall be ensured during the project execution.

2.3. The Solar PV system shall support remote monitoring of important operating parameters such as string voltage/ current, inverter input/ output voltage and current, kW, kWh, Ah, kVAr etc. and also system diagnostic alarms, if any, at a centralized location. The supply of hardware and software required for communication of the solar system over PC including supply and commissioning of all the necessary system shall be ensured.

2.4. Optimization of generation of electricity in terms of kWh generated per KWp of PV capacity installed vis-à-vis available solar radiation at the site shall be ensured (may be obtained through use of efficient electronics, lower cable losses, or maximization of power transfer from PV modules to electronics and the grid, etc.).

2.5. PV modules shall be connected in series-parallel manner to meet the voltage requirement in line with the datasheet of selected Inverter/ PCU. String fuses, sub-array fuses, and array fuses shall be provided in individual strings, sub-arrays, and arrays respectively as per the design requirement specified in IEC 62548 and IEC 60269-6.

2.6. Proper sealing arrangements against rodents/ water at the points of cables entering the enclosures/ buildings should be incorporated.

Latest engineering practice shall be followed ensuring long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

3.0. SPECIFIC TECHNICAL REQUIREMENTS:

3.1. Solar Panels/ PV Modules

- The technical details of Solar PV Modules shall be as given below –

Sl. No.	Description	Details
1	Type of SPV Module	Mono/ Poly Crystalline Silicon
2	Peak Power rating of module	Shall not be less than 250 Wp at Standard Test Conditions
3	Module Efficiency	Shall not be less than 15.5% at Standard Test Conditions
4	Fill Factor	Minimum 0.75

- Codes and Standards

  Shall conform to all the relevant standards, but not limited to the following:

Codes	Description
IEC 61215 / IS14286	Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval
IEC 61730 – 1	Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction
IEC 61730 – 2	Photovoltaic (PV) module safety qualification – Part 2: Requirements for Testing
IEC 62804-1	Photovoltaic modules – test methods for the detection of potential induced degradation – Part 1 : Crystalline silicon

  Compliance to the PID free nature of PV modules shall be established.

- SPV module shall perform satisfactorily in relative humidity up to 95% with operating temperatures between -10°C & +85°C and shall withstand wind speed on the surface of the panel as per site specific requirement.

- The PV modules shall be equipped with bypass diode to minimize power drop caused by shade.

- The module frame shall be made of anodized Aluminium or corrosion resistant material frame, which shall be electrolytically compatible with the structural material used for mounting the modules with sufficient no. of grounding installation. The anodizing thickness shall be 15 micron or more.

- The actual module power capacity shall not vary by more than +3% from its minimum certified module power capacity. No negative tolerance shall be accepted.

- The temperature co-efficient for power output of the Solar PV module shall not be more than -0.42% / °C.

- All photovoltaic modules shall have linear performance warranty from second year. The solar PV modules offered shall not degrade more than 2.5% in first year and not more than 0.7% from second year of its rated power.

- Each Solar PV modules used in solar power plants/ systems must be warranted for their output peak watt capacity, which shall not be less than 90% at the end of 10 years and 80% at the end of 25 years from the completion of the trial run.

- The module mismatch losses for modules connected to an inverter shall be less than 2%.

- Module shall be PID free. The modules shall be provided with anti reflection coating and back surface field (BSF) structure to increase conversion efficiency.

- The SPV module shall be made up of impact resistant, low iron and high transmissivity toughened glass. The front surface shall give high encapsulation gain.

- The SPV modules shall have suitable encapsulation and sealing arrangements to protect the silicon cells from environment. The encapsulation arrangement shall ensure complete moisture proofing for the entire life of solar modules.

- The equipment shall be designed to give efficient and reliable performance and shall be such that the risks of accidental short-circuit due to animals, birds or vermin are obviated.

- The data sheets of all modules shall be provided. The exact power of the module shall be indicated if the data sheet consists of a range of modules with varying output power.

- Module Junction box and Terminal Block shall be of high quality (IP 67 rated) fitted at the back side and shall be weather proof and designed to be used with standard wiring or conduit connection. Each Junction Box shall contain Bypass Diode. They shall have a provision for opening /replacing the cables, if required. The module junction box shall be certified as per IEC 61215.

- Each module shall have two 4 sq.mm. stranded UV resistant output cables each terminated with connectors adaptive to MC4 type connector directly. MC4 type connector should have typical certification from testing agencies such as TUV, competent for the purpose.

- The typical solar PV module electrical characteristics including current-voltage (I-V) performance curves and temperature coefficients of power, voltage and current shall be provided for all the modules supplied. However, the tabulated document with all the relevant data like voltage, current, power output for each module is also required to be provided along with the supply.

- Modules deployed must use a Radio Frequency Identification (RFID) tag for traceability. It shall be well protected within the module laminate and contain the following information:

    a) Name of the manufacturer of the PV module

    b) Name of the manufacturer of Solar Cells

    c) Month & year of the manufacture (separate for solar cells and modules)

d) Country of origin (separately for solar cells and module)

e) I-V curve for the module

f) Wattage, I_{mp}, V_{mp} and FF for the module

g) Unique Serial No. and Model No. of the module

h) Number and Date of IEC PV module qualification certificate

i) Name of the test lab issuing IEC certificate

j) Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001

- 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.

a) Name of the Project, Owner's Name and Logo

b) Manufacturer's Name

c) Model Number, Serial Number

d) Overall Dimensions (WxLxD)

e) Weight (kg)

f) Maximum Power (P_{max}), Voltage (V_{mp}), Current (I_{mp})

g) Short Circuit Current (I_{sc}), Open Circuit Voltage (V_{oc})

h) Main System Voltage

i) Relevant standards, Certification lab. name

j) Warnings, if any

- Testing of Solar PV Modules

PV modules must qualify test from IEC/NABL accredited laboratory as per relevant IEC standard and report/certification of the same must be attached. The performance of PV modules at STC conditions must be tested and approved by one of the IEC / NABL Accredited Testing Laboratories / Solar Energy Centre of MNRE/ any other MNRE authorized test laboratories/centers. The test certificates shall be submitted for acceptability of modules.

3.2. **Module Mounting Structure:**

- The PV modules shall be mounted on metallic structures called Module Mounting Structures (MMS) having adequate strength and appropriate design, which can withstand the load of the modules and design wind pressure.

- Module mounting structure with fixed tilt, south facing orientation and tilted at the location's latitude angle from the horizontal is proposed in order to maximize the total annual incident solar irradiation. However, a different orientation or design may be proposed to achieve better generation with detailed documentary proof.

- The mounting structures shall withstand the maximum wind speed of the location.

- Proper design and calculations report pertaining to foundations and structures duly certified by Chartered Structural Engineer shall be submitted to EIC for approval prior to commencement of work at site.

- Codes and Standards

  Shall conform to all the relevant standards, but not limited to the following:

Codes	Description
UL 2703	Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels
IS 2062	Hot rolled medium and high tensile structural steel — specification
IS 4759	Hot-dip zinc coatings on structural steel and other allied products
IS 2629	Recommended practice for hot-dip galvanizing of iron and steel
IS 3043/IEEE 80	Code of practice for earthing

- The array structure shall be so designed that it would occupy minimum space without sacrificing the output from SPV panels. The structure shall be designed so that repair and maintenance activity could be done easily and shall be in line with the site requirements.

- Adequate walking space shall be made available between the SPV arrays to allow walkway for maintenance personnel.

- All solar panels must be accessible from the top for cleaning and from the bottom for access to the module junction box.

- The module mounting structure members would be made of hot dip galvanized MS profiles in case of ground-mounted systems and penetrating anodized Aluminium structures/ ballasted non-penetrating rails. The minimum thickness of galvanization/ anodization shall be at least 85 microns or higher as per IS 4759.

- In general, bolts, nuts, shims and other hardware shall be SS 304. The generally applicable engineering principle will be that fasteners equal to or greater corrosion resistance than the most corrosion resistant metals being fastened. Standoff materials shall be used to reduce electrochemical corrosion between galvanically dissimilar metal surfaces such as nylon washers, rubber insulators.

  In case of systems using aluminium structure, mounting structure components including T slotted rails, End and mid clamps, angle brackets, and T nuts & bolts should all be made out of anodized Aluminium. The rails riveted to metal rooftop structures shall be done with pop rivets.

- In case of metal roofs with available standing seam, modules shall be preferred to be mounted directly to clamps without requiring roof penetration for riveting. The clamps to be used shall be made out of anodized Aluminium.

- In case of tiled roofs, panels shall be mounted directly to rails fastened to hooks fixed to underlying rafters. The rails and clamps shall be made of anodized Aluminium.

- The weight of the complete solar PV system installed on rooftop shall not exceed 20 kg per sq. mt.

- The minimum clearance of the lowest part of the module structure and the developed/ finished ground level shall not be less than 500 mm in case of ground mounted, 300 mm in case of flat roof mounted and 100 mm in case of slant roof mounted.

- The structure shall support Solar PV modules in portrait orientation, absorb and transfer the mechanical loads to the ground/ roof properly. Welding or complex fixing mechanism shall not be allowed for installation of module mounting structure to the foundation.

- All mechanical items must be supplied as per approved drawing, BOQ and as per direction of EIC.

3.3. **String Monitoring Boxes (SMBs)**

- SMBs shall be used in multi-string photovoltaic systems (≥ 100 kW) to combine the individual strings electrically and to connect them to the Solar Inverters/PCUs.

  For systems of capacity < 100 kW, SMBs need not necessarily be used if String Inverters are used.

- Codes and Standards:

  Shall comply to all the relevant standards, but not limited to the following:

Codes	Description
IEC 62093	Balance-of-System components for Photovoltaic systems-design qualification
IEC 60269-6	Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
IEC 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts
IS 2147/IEC 60529	Degree of protection provided by Enclosures (IP Code)
IEC 61643	Low-voltage surge protective devices
IS 3043/IEEE 80	Code of practice for earthing

- SMB shall be equipped (but not limited to) with the following:

  a) Monitor/ Read the individual string currents, voltage and total current of all the strings connected to SMB. Current and Voltage measurement shall be through shunt based sensors.

b) String fuses, one for each string placed close to SMB in the circuit to prevent the reverse current flow.

c) DC Disconnector/ Breaker placed between String fuse and SMB in the circuit to disconnect each PV strings from the Inverter for maintenance/safety purpose.

d) Type II Surge Protection Devices for protection against surge currents and voltages.

e) Suitable cable entry points with cable glands of appropriate sizes for both incoming and outgoing cables.

f) Suitable markings provided on the bus bar for easy identification, and cable ferrules/ marker strips fitted at the cable termination points for identification.

g) Other associated items such as lugs and items required for the protection and completeness of the system.

h) SMB having processor/ controller to monitor all the above parameters and communicate and transfer the required data to the Remote Monitoring System.

i) Provide a test point for each sub-group for quick fault location.

j) The display of following parameters at Remote Monitoring System for monitoring the health of the each PV string:

   i) Individual string current

   ii) Bus voltage at the output of each SMB

   iii) Total current of SMB

   iv) Total Power of SMB

- DC Surge Protection Devices (SPDs):

  SPD shall consist of three Metal Oxide Varistors (MOV) type surge arrestors which shall be connected from positive and negative bus to earth. As per IEC 61643-11/12, nominal discharge current (I_n) at 8/20 microseconds shall be at least 10 KA with maximum discharge current (I_{max}) of at least 20 KA at 8/20 microseconds. The I_{scwpv} (Short Circuit current withstand capacity) of arrester would be at least 10% more than nominal output current of the combiner box and Array Junction Box. Detailed internal schematic for the above SPDs, compliant to these specifications, shall be submitted by the manufacturers. During earth fault and failure of MOV, the SPD should 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.

- SMB Enclosure shall satisfy following requirements:

  a) Shall be fire retardant with self-extinguishing property and free from Halogen and Silicon conforming to RoHS directive 2002/95/EC.

  b) Degree of protection for enclosure shall be at least IP 65 (for outdoor) or IP 32 (for indoor) and the enclosure shall be UV protected.

c) Shall be double insulated with protection class II as per IEC 61439-1.

d) Separate enclosure for DC disconnector switch shall be provided with min. distance of 1 m from main enclosure.

e) The mechanical impact resistance of enclosure shall be IK 07 or better to protect against impacts as per IEC/ EN 62262 or equivalent standard. Operating ambient temperature rating shall be at least in bracket of -10°C to +60°C. Design calculation verifying the capability of SMB enclosure to withstand temperature rise shall be submitted for PMC/ IOCL approval.

f) Shall be chemically resistant to acid, lye, petrol, and mineral oil & partially resistant to benzene.

g) In each SMB, 5% spare terminals (along with cable glands) rounded off to next higher integer shall be provided to connect the PV strings.

h) Minimum requirements for fire protection in the event of internal faults in accordance with IEC 60695-2-11.

i) Breather glands to prevent overheating and explosions.

3.4. Grid Interactive MPPT Solar String Inverters/ Central Inverters/ Hybrid/ Bidirectional Inverters (with Charge Controllers in case of systems with battery storage)

- The DC power produced by Solar PV Modules shall be fed to the solar inverters/ Power Conditioning Unit(s) (PCUs) for inverting DC into AC power. PCU shall use its MPPT (Maximum Power Point Tracking) control to extract maximum energy from solar array and produce true sine wave 415V AC, 3-ph, 50Hz. For sizing of inverter, the same shall be finalized after submission of proper design calculations duly certified by Chartered Electrical Engineer to EIC for approval. The array output shall be well within the input voltage range of the inverter so that the inverter works in MPPT range for most of the solar insolation range. This should be applicable for the whole life of the solar array and needs to be substantiated through design calculations duly approved by IOCL. PCU shall be able to handle maximum open circuit DC voltage of 1,000V.

- Codes and Standards:

  Shall comply to all the relevant standards, but not limited to the following:

Codes	Description
IEC 61727	Photovoltaic (PV) systems - Characteristics of the utility interface
IEC 61683	Photovoltaic systems –Power Conditioners – Procedure for measuring efficiency
IEC 62116-2014	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures
IEC 62109-1 & 2	Safety of power converters for use in photovoltaic power systems
UL 1741	Standard for Inverters, converters, controllers and interconnection system equipment for use with distributed energy resources

IEEE 929-2000	Recommended Practice for Utility Interface of Photovoltaic (PV) Systems
IEC 62894	Photovoltaic Inverters - Data Sheet and Name Plate
IEC 62910	Utility-interconnected photovoltaic inverters - Test procedure for low-voltage ride through measurements
IEC 62891	Indoor testing, characterization and evaluation of the overall efficiency of photovoltaic grid connected inverters
IEC 61000	Electromagnetic Compatibility
IEC 60068	Environmental Testing
IS 3043/IEEE 80	Code of practice for earthing

For tests like Anti Islanding (IEC 62116) and efficiency measurement (IEC 61683), third party tests from NABL accredited labs shall be acceptable.

- The inverter output shall always confirm to the grid/ captive load bus in terms of voltage and frequency.

- Above 50 KVA, there should be 3 channel of MPPT controllers/ MPPT based solar charge controller to ensure good yield of PV Panels in larger plants.

- Technical details required for Inverters to be installed shall be as under

Parameters	Values
Output frequency	50 Hz ± 0.5% Hz
Maximum Input voltage	1000 V DC
Inverter Output Voltage	415 V ± 1%, three phase, 4-wire output. Nominal voltage could be adjusted ± 5% via system set points. Inverter should work in extremes of the limits in each phase without getting interrupted.
THD (Current)	Less than 3%
Power factor control range	>= 0.9 lead or lag
No load losses	<1% of rated power and maximum loss in sleep mode shall be less than 0.05%
Ambient temperature	-10^0C to $+60^0$C
Humidity	95% non-condensing
Enclosure(type)	IP 32 or better (Indoor rated) IP 65 (Outdoor rated)
Overload Capacity	125% for 10 min and 150% for 1 min 120% at 25^0C continuous on DC side
DC Injection	Less than 0.5% of nominal load current
Electromagnetic Compatibility	As per IEC 61000
Noise level	Less than 85 dB at 1 mt.

- The combined efficiency of the PCU shall be at least 97% at 75% load. The conversion efficiency for PCU at different loads – 10%, 25%, 50%, 75%, 100%, 120% shall be specified in the offer. Above efficiencies are when measured without output inverter transformer.

  The hybrid or bidirectional inverter shall have an efficiency of at least 92% at 75% load.

- PCU shall have Low Voltage Ride-Through (LVRT) feature to provide support during grid fault/ disturbance. Inverter / PCU should also automatically synchronize with the DG set installed when the DGs are available and continue to work at different loads of the site without being switched off / damaged.

- PCU shall have the facility of recording solar energy (KWh) generated at the output of PCU in addition to PV voltage, PV amps, Instantaneous PV power, daily PV power generated & cumulative PV power generated

- Maximum Power Point Tracker (MPPT) shall be integrated in the PCU to maximize energy drawn from the Solar PV array. The MPPT shall be microprocessor based to minimize power losses. The operating voltage range of PCU and the MPPT shall be large enough so that it satisfactorily operates for PV modules exposed to the maximum ambient temperature of 60^0C.

- DC lines shall have suitably rated isolators to allow safe start up and shut down of the system.

- The PCU must have the feature to work in tandem with other similar PCUs and to be successively switched "ON" and "OFF" automatically based on solar radiation variations during the day.

- The PCU shall have anti-islanding protection as per the relevant IEC standards.

- Minimum operating temperature range : (-)10^0C to (+)60^0C

- Remote as well as local monitoring shall be provided. Built-in data logger (to record all the important operational parameters and all the events) to monitor plant performance through external PC shall be provided. The communication shall be in such a way that the PCU can be monitored with the help of appropriate software from the centralized system. The PCU shall have the facility to provide the analysis for reason of tripping, in cases of inadvertent tripping.

- The surge rating of the inverter shall be up to 150% of the continuous rating for a minimum of 30 seconds.

- MOV type surge arrestors shall be provided on all PV inputs for overvoltage protection against lightening induced surges.

- PCU shall have feature to be regulated from 0-99% in steps of minimum 1%.

- PCU shall include ground lugs for equipment and PV array groundings. The DC circuit ground shall be a solid single point ground connection.

- PCU shall have power export control. PCU shall have the facility to export excess PV power to grid in case consumption of load is less than the generation and net/gross metering is available. The provision should be there to enable and disable this export feature.

- PCU shall be tropicalized and design shall be compatible with conditions prevailing at site. Provision of exhaust fan with proper ducting for cooling of PCUs shall be incorporated in the PCUs.

- Nuts, bolts and the PCU enclosure shall have to be adequately protected taking into consideration the atmosphere and weather prevailing in the area.

- **Display:**

  PCU shall have the facility to display the basic parameters of the system on in-built LED/ LCD display on its front panel or on separate data logging/ display device to display following or through any other indication means:

  a) DC Input Voltage

  b) DC Input current

  c) AC Output Voltage

  d) AC Output Current

  e) AC Power output (kW)

  f) AC Energy output (KWh)

  g) Frequency

  h) Temperatures (^{0}C) : Ambient as well as internal

  i) Over frequency

  j) Under frequency

  k) Inverter ON/OFF

  l) Grid ON/OFF

  m) Inverter over-load

  n) Inverter over-temperature

  o) Battery Voltage and Current (in case of hybrid systems with battery)

- Protections:

  Following is an indicative list of protections (the actual scheme shall be finalized at design stage):

  a) Over-voltage both at input and output

  b) Over-current both at input and output

  c) Over/under grid/bus frequency

  d) Over temperature

e) Reverse polarity protection

f) Array ground fault protection

g) Protection against earth leakage faults (DC as well as AC side)

h) Protection against lightning induced surges

i) Protection against surge voltage induced at input and output due to external source

j) Provision for input & output isolation.

k) PCU shall have arrangement for adjusting DC input current and should trip against sustainable fault downstream and shall not start till the fault is rectified.

In addition, PCU shall ensure following protection measures:

- MCBs/ MCCBs shall be provided for systems connected to PCU/ Inverter (i.e. Solar PV system, Battery System (in case of hybrid system with battery), Captive Load System or Mains System).
- 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 PCUs safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU diagnostic circuit 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.
- Automatic reset of all non-critical faults such as overloads, AC over voltage/under voltage, etc. once the fault has been cleared.

- Operating modes of PCU:

a) LOW VOLTAGE MODE: The control system shall continuously monitor the output of the solar PV plant. Once the pre-set value is exceeded, PCU shall automatically "wake up" and begin to export power provided there is sufficient solar energy and the PCU voltage and frequency are in the specified range.

b) ACTIVE Maximum Power Point Tracking (MPPT) MODE (HIGH POWER MODE): When solar radiation increases further, the PCU shall enter Maximum Power Point Tracking (MPPT) mode and adjust the voltage of the SPV array to maximize solar energy fed into the grid. When the solar radiation falls below threshold level, the PCU shall enter in low power mode.

c) SLEEP MODE: Automatic 'sleep' mode shall be provided so that unnecessary losses are minimized at night.

- DC side of each inverter shall be earthed to distinct earth pit through adequate size conductor as per IS 3043. The size of conductor shall be as per the maximum fault current on DC side.

- The PCU shall withstand the environmental tests as per IEC 60068/IS 9000, with the PCU working at full load for at least last half an hour. Environmental test results in respect of any similar design PCU for at least 100 KWp SPV systems will be adequate.

- In case of hybrid system with battery storage solution, following minimum features shall be guaranteed in the PCU:

  a) The MPPT based solar charge controller shall comply with IEC 62093, IEC 62509 and IEC 60068-2.

  b) Accuracy class 0.5 Ah meter to measure the cumulative charging and discharging status of battery bank.

  c) The MPPT based solar charge controller shall guarantee following minimum features:

    i) Battery current limiting feature to avoid over charge into the batteries

    ii) Optimization of battery life and backup power supply - Design basis document duly certified by Chartered Electrical Engineer to be submitted.

    iii) Battery and PV reverse polarity protection (no use of blocking diodes which reduces overall efficiency of the system)

    iv) Rated MCCB/ MCB on all PV inputs & battery inputs.

    v) Facility to communicate with Remote Monitoring System for all important parameters.

    vi) Efficiency of Charge Controller $\geq$ 90%

    vii) Warranty: 5 years (standard) / 10 years (Optional)

    viii) Environmental Testing: IEC 60068-2 (1, 2, 14, 30)/Equivalent BIS Std. Conformance test certificate to be submitted by successful bidder.

  d) A bidirectional inverter unit shall be used such that the same circuit elements are used for performing inverting and battery charging (through mains) operation, if required. It should be an IGBT based; microprocessor controlled inverter & should incorporate PWM technology and all the desired safety features for reliable running of PCU.

    Following minimum features should be ensured in such bidirectional inverter unit:

    i) Operation without any derating from 0-50 degrees of ambient temperature

    ii) Minimum overload capability of 110% for 60 sec, 125% for 30 sec and 150% for 5 sec.

    iii) Inverter should be able to sustain load imbalance between the phases. It is important as different phases may have different loads and hence it shall be checked/defined to ensure that PCU is working even if say, R phase has 10% load while Y-phase has 5% load and B-phase has 100% of its rated load.

    iv) Automatic reset of all non critical faults such as overloads, AC over voltage/ under voltage etc. once the fault has been cleared.

    v) Facility to export excess PV power to grid in case consumption of load is less than the generation. Provision should be there to enable & disable this export feature. However load should remain and be supplied from the solar power and only balance power exported.

    The mains based battery charger should incorporate following minimum features:

    i) Facility to bypass grid to loads and charge batteries at the same time.

    ii) Should be IGBT based for rugged operation.

iii) Should use AC supply of all the three phases and not single phase.

iv) Should have a peak efficiency of at least 85% for AC to DC conversion.

v) 3 stage (float, boost and equalize) battery charging for long life of the battery.

vi) Facility to enable/disable charging of battery through mains by controlling the import power from mains.

vii) Facility to communicate with Remote Monitoring System for all critical parameters such as Inverter voltage/ current/ frequency, Mains voltage/ current/ frequency, Battery voltage and current, as well as all active faults.

3.5. **ACDB with manual rotary bypass changeover**

- 3-phase, 50 Hz, 415V AC switchgear system shall be used if multiple Inverters/PCUs are selected. LT Switchgear board/panel shall be provided between inverter transformer and captive load bus.

- The ACDB shall have necessary protection devices, i.e. MCB/ MCCB, ELCB, Surge Protection Devices, and Disconnectors/Isolators.

- The ACDB shall have manual rotary bypass changeover switch.

- All the electrical components shall be housed in IP 65 metal enclosure.

- The incoming and outgoing cables shall have proper cable gland arrangement for cable terminations.

- The rating of electrical protection systems installed in ACDB shall be duly certified by Chartered Electrical Engineer and approved by EIC.

3.6. **AC LT Breaker Feeder/ AC Switchgears**

- The scope shall include standard load distribution boards/panels complete with cubicles, protection, metering, bus-bar system, cabling, wiring and other accessories, the quantities/ratings of which shall be finalized during detail engineering, duly certified by Chartered Engineer and approved by EIC.

- All the above boards/panels shall be metal enclosed, 415V switchgear type, complete with suitably rated:

  a) Draw out type Air Circuit Breaker

  b) Surge Protection Devices

  c) Required no. of MCCBs and ELCBs

  d) Numerical Relays, with the provision of in-built event logger

  e) Required no. of Multifunction meters

  f) Bus bars

  g) Local control switches

  h) Indicators (LED type) as per requirement

i) All necessary auxiliaries for control and supervisory circuits, and other relays as required

j) All secondary wiring, terminal blocks, labeling and nameplates, sockets etc.

k) Cubicle lighting including lighting fixtures and power and communication sockets

l) Space Heaters

m) Coordination and provision of necessary contacts and/or ports for integration with Remote Monitoring system

n) Any other item(s) not mentioned specifically but necessary for the satisfactory completion of system will be in scope of supply.

- Technical Requirements:

Location	Indoor
No. of bus bars, 3-phase	1
Rated voltage , V	As per the system configuration requirement
Rated frequency Hz	50 ± 0.5 Hz
Rated circuit breaker short circuit breaking capacity	50 KA
Protection Class	Min. IP 32 or better as per requirement of location
Control voltage, DC	Uninterrupted supply through power pack/UPS with voltage level as per system requirement
Auxiliary AC supply, 3 phase	415 ± 10 %
Material of Bus bar	Aluminum alloy / copper
Type of Earthing	Solidly earthed

- Codes and Standards:

Shall comply to all the relevant standards, but not limited to the following:

Codes	Description
IS/IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60439 / IS 8623	Low-voltage switchgear and control gear assemblies
IEC 60364	Low-voltage electrical installations
IS/IEC 60947	Low-voltage switchgear and control gear
IS 3072	Code of practice for installation and maintenance of Switchgear
IS 3231	Electrical relays for power system protection
IS 13703 / IEC 60269	Low voltage fuses for voltage not exceeding 1000 V AC or 1500 V DC - specification
IEC 61643	Low-voltage surge protective devices
IS 3043/IEEE 80	Code of practice for earthing
IS 14697	AC Static Transformer Operated Watt-hour and VAr-hour Meters - Class 0.2 S and 0.5 S - Specification

- Power bus-bars and insulators shall comply with specifications as given in standards/codes, ensuring adequate operational and safety features. Calculations establishing the adequacy of bus bar sizes for specified current ratings duly certified by Chartered Electrical Engineer shall be submitted for approval of EIC before placing the order/start of construction of LT Switchgear unit.

- Adequate protection measures shall be ensured through means of Circuit Breakers, MCCBs, Contactors, Surge Protection Devices and Fuses. The design selection of such components shall be ensured as per the system requirement and adequate design calculations/basis duly certified by Chartered Electrical Engineer shall be submitted for approval of EIC before placing the order/start of construction of LT Switchgear unit.

  All the necessary test certificates shall be submitted to establish the compliance of these protection equipment(s)/ components to the operational requirements outlined in the respective codes and standards.

- It shall be ensured 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 standards and codes. Continuous current rating at 50^0C ambient in no case shall be less than 90% of the normal rating specified. The derating factors, if any employed for each component and the basis for arriving at these derating factors shall be clearly specified, duly considering the specified current ratings and ambient temperature of 50^0C.

- Internal wiring shall be ensured through proper sizing wire, the design current carrying capacity of which shall be less than 2A/mm^2 for flexible copper cables/wire. All the internal wiring shall be done through properly chosen color coded wires and neatly dressed for easy identification.

- The protection coordination and interlocks shall be ensured. The schematics for the same duly certified by Chartered Electrical Engineer shall be submitted for approval of EIC before final configuration.

- Following drawings and manuals shall be submitted in three copies.

  a) General arrangement of panel showing overall dimensions with foundation plan, terminal location, total weight, sectional views, operating mechanism, and Bill of materials

  b) Schematic and wiring diagram for control logic/ circuitary

  c) Closing and Opening timing charts of main and auxiliary contacts

  d) Manufacturing schedule and test schedule

  e) Instruction manual along with O&M manual and individual components' catalogue

- There should be for measurement and display of Solar Power being fed to the load bus. System should also have the capability to display the minimum, maximum and average solar power being fed to the system on daily/monthly/yearly basis.

- The system should also be capable to measure, register and display the solar energy consumption on daily/monthly/yearly basis. The energy meter must show the exact line current, voltage, instantaneous power and energy reading (daily & cumulative).

- The metering facility of the system shall comply following minimum specifications:

  a) Solar system metering should work accurately for the complete range of energy, voltage, current, frequency and power factor envisaged for this installation. Cumulative KWH will be indicated continuously by default & other parameters through push-button flashing LED visible from the front.

  b) In case the state in which the project is planned has net/gross metering facility, installation of necessary meters (bi-directional meters with accuracy class 0.2S, or as prescribed by State Regulatory Authorities) shall be ensured.

  c) Applicable standards for energy meters (as per the accuracy class requirement):

     ✓ IS 14697 – For Class 0.2 and 0.5
     ✓ IS 13010 – For Class 0.5, 1 and 2

  d) Accuracy Class Index of communicable multi-function energy meter: 1 or better.

  e) Memory: Non volatile memory independent of battery backup, memory should be retained up to 1 year in case of power failure.

  f) Software and Communication Compatibility: Shall be compatible to communicate and transfer all types of instantaneous and cumulative energy metering data with the Microprocessor based Data Logger System through RS-485 port. All types of necessary software and hardware to connect the meter with Microprocessor based Data Logger System shall also be supplied.

  g) Climatic Condition: The meter should function satisfactorily in India with high end temperature as 60ºC and humidity up to 95%.

3.7. **Inverter Transformers**

- Inverter transformer (dry type or oil filled) shall be provided as close as possible to Inverter(s)/ PCU(s) for galvanic isolation and the primary winding voltage rating of the transformer shall match the inverter output voltage and secondary winding voltage rating of the transformer shall match the captive load bus voltage (415V).

  The same can either be housed within the Inverter unit with separate enclosure to ensure that the Inverter unit is not heated or be housed outside very close to Inverter Unit with necessary foundation and protection systems.

  The transformer shall be suitable for semi outdoor conditions and shall have self supporting structure with top lifting arrangement.

- Suitable rating MCB/ MCCB provision shall be made available at transformer output with proper disconnectors.

- Technical Requirements:

Transformer	Dry-type Power Tranformer	Oil-filled Power Transformer
VA Rating, Quantity, and Voltage Ratio (KV)	As per system requirement and SLD	As per system requirement and SLD
Duty, Service & Application	Continuous Solar Inverter application (Outdoor)	Continuous Solar Inverter application (Outdoor)
Type	Cast resin core dry type transformer with encapsulated winding	Cast resin core oil filled transformer with encapsulated winding
Efficiency	>98%	>98%
Winding	As per SLD	As per SLD
Winding Material	Electrolytic grade copper	Electrolytic grade Aluminium or copper
Vector Group & Neutral earthing	As per system requirement and SLD	As per system requirement and SLD
Cooling	Natural Air Cooled (AN)	ONAN
Tap Changer	As per system requirement and SLD (Desirable at ±2.5% and ±5% with tap links accessible)	As per system requirement and SLD (Desirable at ±2.5% and ±5% with tap links accessible)
Enclosure	IP32 (semi outdoor application)	IP32 (semi outdoor application)
Insulation	Class F (Epoxy encapsulated)	Class A
Insulation Level	Rated short duration withstand voltage as per IS 11171	As per IS 10028-2
Impedance Voltage	As per IS 2026; no negative tolerance allowable	As per IS 2026; no negative tolerance allowable
Operating ambient temperature	50^0C	50^0C
Permissible Temp. rise over an ambient temp. of 50^0C (irrespective of tap)		
a) Top Oil	NA	50^0C
b) Winding	NA	55^0C
SC withstand time (thermal)	2 sec.	2 sec.
Fault Level & Bushing CT	NA	As per system requirement and SLD
Noise level	As per NEMA TR-1	As per NEMA TR-1
Loading Capability	Continuous operation at rated MVA on any tap with	Continuous operation at rated MVA on any tap with voltage

	voltage variation of +/- 10%, also transformer shall be capable of being loaded in accordance with IS 6600 / IEC60076- 7.	variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS 6600 / IEC60076- 7.
Impedance at 75°C	As per IS 2026; no negative tolerance allowable	As per IS 2026; no negative tolerance allowable
Air clearance	As per CBIP	As per CBIP
Cable Glands	Suitable number as per the system requirement and SLD	Suitable number as per the system requirement and SLD
Terminals	Terminal box shall be provided with tin plated flat copper terminals for required number terminals suitable for adequate size copper terminals. Cable glands of suitable size with neoprene gasket shall be provided. Transformer shall have top cable entry. Both primary and secondary terminals shall be brought on one side of the transformer.	Terminal box shall be provided with tin plated flat copper terminals for required number terminals suitable for adequate size copper terminals. Cable glands of suitable size with neoprene gasket shall be provided. Transformer shall have top cable entry. Both primary and secondary terminals shall be brought on one side of the transformer.
Inspection cover	Should be removable from front.	Should be removable from front.

- Codes and Standards:

  Shall comply to all the relevant standards, but not limited to the following:

Codes	Description
Transformers	
IS 2026/IEC 60076	Power Transformers
IS 11171	Specification for dry-type power transformers
IS 6600	Guide for loading of Oil-immersed transformers
IS 3639	Specifications for fittings and accessories for Power Transformers
IS 3637	Specifications for gas operated relays
IS 10028	Code of practice for Selection, Installation and Maintenance of transformers
IEC 60551	Determination of transformer and reactor sound levels
Bushings	

IS 7421	Specifications for Porcelain Bushings for Alternating Voltages up to and including 1000V
Insulating Oil	
IEC 60296	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear
IS 335	New Insulating Oils - Specifications
Bushing CTs	
IS 2705	Current Transformers - Specifications
IEC 60185	Current transformers
Other Relevant Codes/Acts/Guidelines	
Indian Electricity Act	
Indian Electricity Grid Code	
BEE Guideline	
CEA Notifications & CERC Guidelines	

- Standard construction philosophy shall be adopted in construction of transformers, complying with national and international standards as well as Indian Electricity Grid Code and CEA/CERC guidelines. The transformers shall be so designed that it meets the intended operational parameters for the entire lifetime of the Solar PV plant (considered here as 25 years).

- The design basis document for transformer selection (consisting of all the transformer components) duly certified by Chartered Electrical Engineer shall be submitted to EIC for approval before placing the order.

- The transformer shall be placed in semi outdoor confined compartment with flap /hinge type doors, where only two sides will be accessible and open to free air for ventilation. The other two sides shall be very close to compartment walls and free air ventilation will be obstructed. This aspect should be taken care during design of transformer.

- The power supply to transformer may contain significant spikes and harmonics generated by thyristor converters, hence the design of transformer should be suitable for spikes & harmonics.

- Temperature rise & terminal marking of the transformer shall be as per IS 11171:1985. SC withstand ability of transformer shall be as per IS 2026:1977.

- 2 Nos earthing point shall be provided at the bottom of the transformer for earthing of transformer enclosure.

- Transformer shall be provided bi-directional roller with locking arrangement for easy movement.

- All hardware used for transformer assembly shall be zinc plated & passivated.

- Transformer core shall be earthed to main frame of the enclosure at two independent points.

- The construction of transformer shall be rugged enough to withstand frequent transit & vibration during transportation from one site to another and during operation.

- Transformer shall be provided with suitable rating plate, diagram plate & lifting lugs. Supplier to ensure that lifting lugs have sufficient safety factor and high tensile strength suitable to take transformer load.

- Transformer to be painted as per standard industrial painting process however painting should be resistant to various chemicals used in oil industry and other hydrocarbon based fumes.

- Cable terminal identification label of approximate 60 x 60mm size to be provided near glands for identification.

- Only tinned copper or phosphor bronze washer / spacer to be used. Also phosphor bronze screws shall be used, wherever required.

- Tubular insulators are not acceptable. Only epoxy insulators to be used, wherever required.

- Enclosure sheet of transformer shall not be less than 2mm thick sheet steel with louvers at all sides.

- Stainless steel / Anodised aluminum rating plate shall have information as per IS 11171-1985. Following minimum information to be provided necessarily on the rating plate:

    - Transformer type
    - IS followed
    - Manufacturers name
    - Manufacturers Sl No for the transformer
    - Year of manufacturing
    - Class of insulation
    - Max possible temperature rise
    - No of Phases
    - Rated Frequency
    - Rated Voltage including tapping
    - Rated current for each winding
    - Connection symbol
    - Vector group
    - Type of cooling
    - Total weight

    Details of rating plate to be submitted by the Contractor for approval after placement of PO.

- The other important construction particulars shall be as below

    - 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.

    - A double float type Buchholz relay shall be provided.

    - 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.

- 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.

- 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.

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

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

- Marshalling Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 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.

- Transformers shall withstand, without injurious heating, combined voltage & frequency fluctuations, which produce the following over fluxing condition:

  110 % - Continuous

  125% - for one minute

  140% - for five seconds

- The other parameters of oil before filling in the transformer tank shall be limited to following:

  Break down voltage: 70 kV at 2.5 mm gap

  Moisture content: less than 5 ppm

  Gas content: less than 0.1% by volume

- The Type Test & Routine test of the transformer shall be carried out in accordance with IS: 2026. All relevant type test and routine test certificates shall have to be submitted.

3.8. **Earthing and Lightning Protection**

- The photovoltaic modules, mounting structure, Balance of system (BOS) and other components of power plant require proper grounding for protection against any serious earth faults.

- Redundant earthing methodology with two independent earth connections from each system has to be ensured for all the systems and equipment as given in the standards.

- Technical Requirements:
  - There shall be separate earthing provision for:
    - Inverter room or invertors/ PCUs and Remote Monitoring System
    - Module Mounting Structure
    - Lightning arrestor
  - All the electronic earthing shall be done through insulated cable from equipment to earth grid.
  - The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.
  - The material of the earthing conductors shall be as follows:
    - Conductors above ground level – 32 mm x 6 mm GI Strip
    - Conductors buried in earth – 50 mm x 6 mm GI Strip
    - Earth electrodes -80 mm NB Heavy perforated GI Pipe
  - 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.
  - 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.
  - Earth pit shall be constructed as per IS:3043. Electrodes shall be embedded below permanent moisture level. Earth pits shall be treated with salt and charcoal if average resistance of soil is more than 20 ohm meter. 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. Earth pit inner to be of minimum 450 mm x 450 mm.
  - In general industrial practice, the standard philosophy of providing redundancy by facilitation of two point contacts between structure and grid, or structure/ equipment and earth pits (GEP or NEP), or structure and structure has to be ensured.
  - Solar Array Earthing

    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, etc. shall be effectively earthed by two separate and distinct connections to earthing system. Equipment and structure in the solar farm shall be earthed in compliance to the IS: 3043 (Code of Practice for Earthing) and Indian Electricity Rules/Acts.

- 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. .

- 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.

- The earthing resistance must not exceed the limits generally in practice for such applications i.e. 1Ω.

- Codes and Standards:

  Shall comply to all the relevant standards, but not limited to the following:

Codes	Description
IS 3043	Code of practice for Earthing
IEEE 80	IEEE guide for safety in AC substation grounding
IEEE 142	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
IS 2309	Code of Practice for the protection of building and allied structures against lightning
IEC 62305	Protection against Lightning
IS 4736	Hot-dip Zinc coatings on MS Tubes
Other Relevant Codes/Guidelines/Acts	
Indian Electricity Act Indian Electricity Rules	

- The source of over voltage can be lightning or other atmospheric disturbance. Lightning Protection System (LPS) i.e. lightning conductors or mesh shall be provided so as to prevent direct lightning strike into the PV modules. It is to be ensured that adequate separation distance is kept between the LPS and PV modules. Main aim of over voltage protection is to reduce the overvoltage to a tolerable level before it reaches the PV or other sub-system components.

- The Station/ Intermediate Class Early Streamer Emission (ESE) technology Lighting Arrestor (LA) has to be designed as per applicable standards so that whole of the Solar PV Plant is protected. Design basis report duly certified by Chartered Electrical Engineer has to be submitted prior to finalization of drawings for approval of EIC.

- Down conductors for lightening protection shall be as short and straight as practicable and shall follow a direct path to earth electrode. Each down conductor shall be provided with a test link at 1000 mm above ground level for testing but it shall be inaccessible to interferences. No connections other than the one direct to an earth electrode shall be made below a test point. All joints in the down conductors shall be welded type.

- Each LA shall have to be earthed through suitable size earth bus with separate earth pits.

- Necessary concrete foundation or any other arrangement for holding the lightning conductor in position is to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.

- The lightning conductor and structures shall be earthed through flats as per applicable standards with earth pits. Each lightning conductor shall be fitted with individual earth pit as per required standards including accessories, and providing masonry enclosure. Else, a matrix of lightning conductors is to be created which will be required to be connected to an earth.

- The scheme, drawings and detailed specifications of the PV array lightning protection equipment and earthing arrangement duly certified by Chartered Electrical Engineer shall be submitted for EIC approval.

3.9. **Remote Monitoring System (RMS)/ Microprocessor based Data Logger System:**

- The plant parameters shall be measured using Microprocessor based Data Logger System or an equivalent system deployed to monitor the plant centrally and also to study the plant performance. All the parameters from different array/systems at various locations, individually and combined together, must come to the central system to provide a live and comprehensive view of the entire solar plant with continuous alert system. The remote monitoring system shall be capable to monitor and record at local monitoring system to be provided at the project site and if possible, compatible to be viewed from anywhere through internet cloud network. The system shall be in accordance with IEC 61724. The Microprocessor based Data Logger system shall have spare capacity with provision of at least 25% expansion without any software or hardware up-gradation at Microprocessor based Data Logger system end and further licensing so that any future solar project can be integrated with the same system. The plant monitoring parameters shall include:

    - PV array energy production: Communicable multi-function energy meters logging the actual value of DC and AC Voltage and Current & Energy generated by the PV system and subsequently by PCU shall have to be provided.
    - Solar PV Plant Energy production: Total energy generation (DC) from Solar PV Power Plant as measured at energy meter installed in Solar PV Plant Inverter/PCU input. This reading shall be treated as final energy generation from Solar PV Power Plant for evaluation of Performance Guarantee.
    - Solar Irradiance: One no. of integrating Pyranometer (Class II or better) shall be provided, with its sensor mounted in the plane of the array. Readout shall be integrated with Remote Monitoring System. The pyranometer must have an accuracy > 98%. Test certificate for the same shall be submitted. Pyranometer shall be capable to provide integrated total irradiation (in kWh/m^2) as well as average irradiation (in W/m^2) at an interval of every 1-minute. Pyranometer shall have communicable RS-485 port.
    - Temperature: Temperature probes/meters for recording the module temperature shall be provided. Readout shall be integrated with Remote Monitoring System. The permissible error in the reading shall be $\pm 0.5^0C$. Test certificate for the same shall be submitted. Temperature probes/meters shall have communicable RS-485 port.
    - Percentage controller regulation value from Solar Grid DG Management System shall be made available.

- Electrical performance parameters: All the electrical parameters have to be provided in Microprocessor based Data Logger system. The performance logs from individual electrical equipments/devices have to be made available in Microprocessor based Data Logger system with a sampling time as given in the standards.
- Data Log Report: Microprocessor based Data Logger system should be programmed to generate data log report on a daily, monthly and annual basis. All the key parameters necessary to evaluate the plant performance shall be integrated in this report after finalization of the same. All the values shall correspond to system clock time at the time of recording and in all the reports generated.

- All the values corresponding to above mentioned parameters shall be recorded with respect to independent system clock of Remote Monitoring System.

- Monitoring System shall generate GHI value, Generation value (from the DC energy meter installed at Inverter/ PCU Input), module temperature value, and percentage controller regulation value (derived from Solar Grid DG Management System) on instantaneous/average/integrated basis. The same shall be used to assess the system performance and to establish Performance Guarantee Test (PGT) of the system as described in the SCC. The controller regulation percentage based on the operational requirement of DG upon unavailability of Grid shall be fed to the monitoring system through proper wiring/cabling, or through other communication medium as may be deemed fit.

- Technical Requirements:
  - Microprocessor based Data Logger system shall have the provision to perform the following functions:
    - Acquisition and display of data, status, and trends at local monitoring system setup
    - Monitoring of all the parameters from Switchgears (especially numerical relays) and Inverters
    - Display and storage of measured values at local monitoring system
    - Display and storage of derived/calculated/integrated values at local monitoring system
    - Display and Storage of events and trends at local monitoring system
    - Generate, store and retrieve Event Reports from Inverters/PCUs and Numerical Relays at local monitoring system
    - Generate, store and retrieve user configurable Periodic Reports
    - System self-supervision
    - Backup facility for data backup at every three/six months on CD-ROM/tapes
  - SMS generation feature for at least 5 predefined contact numbers shall be made available on Plant Trip/any operational deviation.
  - A graphical daily and monthly generation report as well as generation w.r.t. radiation shall be made available at local monitoring system to be setup. The data from this local monitoring system shall be made available on internet cloud network provided along with the Data Logging System.
  - The following data to be monitored:

- Grid summary
  - ✓ AC output voltage
  - ✓ KVA
  - ✓ Frequency
- Inverter summary
  - ✓ DC Energy Input (key parameter to be used for Plant Performance evaluation)
  - ✓ AC output voltage
  - ✓ KVA
  - ✓ Frequency
  - ✓ Power Factor
  - ✓ Current
  - ✓ Exported power (kW)
- DC summary
  - ✓ DC voltage
  - ✓ Current
  - ✓ DC power input
- Site Summary (Field data) and other data
  - ✓ Solar Insolation Data
  - ✓ Module temperature
- Solar Power Plant generation
  - ✓ DC Energy Meter at Inverter/PCU Input
  - ✓ AC Energy Meter reading at Captive Load Bus
- Battery Bank, in case of hybrid systems with battery
  - ✓ Battery terminal voltage and current
  - ✓ Ah meter reading

- Codes and Standards:

  Shall comply to all the relevant standards, but not limited to the following:

Codes	Description
IEC 61724	Photovoltaic System Performance Monitoring – Guidelines for measurement, data exchange and analysis

- Data logging system/software shall allow visualization, monitoring and service of the installation. The data logger shall be also web enabled. It should be possible to access the data logger with any standard web browser like Internet Explorer, Google Chrome, Mozilla,

Safari etc. and for this purpose, relevant software/ hardware will be supplied by the successful bidder. In addition to the web portal, it should also be possible to retrieve the data directly from the data logger. The software for access/ visualization of data from data logger should also be provided. Necessary executable files, if any, will be required to be given on a CD/any other storage device along with lifetime license (if applicable).

- Communication interface: The system should offer minimum 40 communicable ports (RS485 preferably) interface to facilitate monitoring of the system at local monitoring system.

- Local Monitoring System: One compatible computer along with accessories, all installed and in ready to use condition (Minimum requirement: Workstation CPU with Intel® Core® i3 Processor, 4GB RAM, 1TB Hard Disk, Windows 10, 64-Bit operating system, 14 Inch Monitor, Optical Mouse, Qwerty keyboard) to host the necessary software shall be supplied. All necessary components, cables, software to connect with this shall also be supplied. The provision to house this system for local monitoring shall be provided in a separate cabin inside the Inverter Room by the Contractor.

- A internet /dongle service shall be ensured to communicate this local monitoring system through internet cloud network provided along with the Data Logging System. The data storage shall be ensured in the hard-disk of local monitoring system which shall be accessed through suitable software and internet facility for remote access through cloud network.

- A complete and comprehensive "RMS monitoring solution" report shall be made available to –

  i) know what is produced in real time

  ii) have detailed analytics to understand if the power generated is 'as expected/designed', and

  iii) know any issues with field equipment and correct, through effective O&M.

- The UPS based AC Power supply of suitable rating to cater all the load requirements of Microprocessor based Data Logger system and its auxiliaries shall be provided. The power backup for the entire system should be at least for 30 minutes.

3.10. **Cabling:**

- The DC Cable shall be 1.5 kV (DC) grade, heavy duty, compacted aluminium/copper conductor, UV resistant XLPE insulated, PVC inner-sheathed, galvanized steel wire/strip armored, fire/flame retardant low smoke FRLS PVC outer sheathed. The cables shall in general conform to IS 7098 (Part-I).

- The power cable shall be 1.1 kV grade, heavy duty, stranded copper conductor, UV resistant (for outdoors) PVC type-A insulated, galvanized steel wire/strip armored, fire/flame retardant low smoke (FRLS) extruded PVC type ST-1 outer sheathed. The cables shall, in general, conform to IS 1554 Part-I&II and other relevant standards.

- Control Cables: The cable shall be 1.1kV grade, heavy duty, stranded copper conductor, PVC type-A insulated, galvanized steel wire/strip armored, flame retardant low smoke (FRLS) extruded PVC type ST-1 outer sheathed. The cables shall, in general, conform to IS 1554 Part-I & other relevant standards.

- Technical Requirements:
  - Solar cables must have TUV certification
  - Straight through joints should be avoided.
  - The cables shall have an ambient operating temperature range of -10^0C to $+60^0$C.
  - Cable terminations shall be made with suitable cable lugs & sockets etc., crimped properly and passed through brass compression type cable glands at the entry & exit point of the cubicles.
  - The cables shall be adequately insulated for the voltage required and shall be suitably color coded for the required service.
  - All power cables shall be tested at the site as per the standard in front of EIC/nominated officer present at the site. The Cables shall also confirm to IEC 60189 for test and measuring methods and they should be UV Protected. No cable should be left open.
  - Data sheets of individual cable sizes shall be submitted. Drum numbers and drum length details shall be submitted with each consignment.
  - Cables must be selected so as to minimize the risk of earth faults and short-circuits. All exposed DC cables must be flexible single core and must satisfy the above criteria.
  - XLPE insulation shall be suitable for a continuous conductor temperature of 90^0C and short circuit conductor temperature of 250^0C.
  - PVC insulation shall be suitable for continuous conductor temperature of 70^0C and short circuit conductor temperature of 160^0C.
  - All the cables of size 50 mm^2 or higher shall be armored, to fetch mechanical protection of sheath, insulation and conductor.
  - If the data transmission length is more than 100m distance or as required, Optical Fiber cable shall be used.
  - De rating factors for various conditions of installations, including the following, shall be considered while selecting the cable sizes:
    - Variation in ambient temperature for cables laid in air
    - Grouping of cables
    - Variation in ground temperature and soil resistivity for buried cables
  - Following minimum marking shall be provided on the outer sheath -
    - Cable size and voltage grade
    - Word 'FRLS' at every 5 mt
    - Sequential marking of length of the cable in mt at every 1 mt

    In addition, the printing shall be progressive, automatic, in line and marking shall be legible and indelible.
  - Cables are to be routed neatly in standard manner through GI perforated cable trays & cable marker to be placed for future identification. For array wiring, suitable cable tray or metal conduit with proper support shall be provided and fastened in accordance with relevant standards, industry codes and Indian Electricty Grid Code.

- Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 meter. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be minimum 2 mm. The thickness of side coupler plates shall be minimum 3 mm.
- For protection of unarmored cables, suitable conduits shall be provided.
- The switches/circuit breakers/connectors required should conform to IEC 60947 (Part-I, II & III) or IS 60947 (Part-I, II & III) EN 50521.

- Codes and Standards:

Codes	Standards
TUV specification 2 Pfg 1169/08.2007	DC cable for photovoltaic system
IS 1554 (Part-I)	Specification for PVC insulated (Heavy Duty) electric cables: for working voltages up to and including 1100V
IS 1554 (Part-II)	Specification for PVC insulated (Heavy Duty) electric cables: for working voltages from 3.3kV up to and including 11kV
IS 3961	Recommended current rating for cables
IS 3975	Low carbon galvanized steel wires, formed wires and tapes for armouring of cables – Specifications
IS 5831	PVC insulation and sheath of electrical cables
IS 7098 (Part-I)	Specification for Cross linked polyethylene insulated PVC sheathed cables for working voltage up to and including 1100V
IS 7098 (Part-II)	Cross linked polyethylene insulated thermoplastic sheathed cables for working voltages from 3.3kV up to and including 33kV
IS 7098 (Part-III)	Cross linked polyethylene insulated thermoplastic sheathed cables for working voltages from 66kV up to and including 220kV
IS 8130	Conductors for insulated electrical cables and flexible cords
IS 10810	Methods of test for cables
IEC 754	Test on gases evolved during combustion of materials from electric cables
IEC 332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B)
IS 10418	Specification for drums for electric 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 (Oxygen Index)

- Cabling on DC side of the system shall be as short as possible to minimize the voltage drop in the wiring. Voltage drop on the DC side from array to the inverter should not be more than 2%. In the light of this fact, the cross-sectional area of the cable should be so chosen such that the voltage drop introduced by it shall be within 2% of the system voltage at peak power. Necessary design calculations in this regard duly certified by Chartered Electrical Engineer shall be submitted to EIC for approval.

- For the AC cabling from inverter/PCU to existing Feeder Bus, armored PVC insulated cables shall be used. The sizing of cable shall be based on the maximum load flow considering the voltage drop within the permissible limit of 3% and maximum short-circuit withstand capability. The design calculations for sizing of the cable duly certified by Chartered Electrical Engineer shall be submitted for EIC approval. The complete cable shall be laid through trench or tray (including preparation of trenches and trays with manpower and material, if required) and proper arrangement shall be made for end termination, glanding and lugging with supply of material.

- Overload protection is to be provided. Design Overload capacity of 125% of continuous rating for 10 sec has to be ensured. The principle aim for this protection is to reduce the over voltage to a tolerable value before it reaches the PV or other subsystem components. The source of over voltage can be lightning or any other atmospheric disturbance or internal system disturbance.