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BAY OF BENGAL POWER COMPANY LIMITED

Volume 2 A

TENDER DOCUMENT

FOR

**Design, Supply, Installation, Testing & Commissioning of 160
MW Solar (AC) PV Power Plant at Moheshkhali Peninsula,
Cox’s Bazar District, Bangladesh.**

(One Stage Two Envelope Tendering Method)

AGAINST TENDER REFERENCE No.: BBPCL/Maheshkhali-1320MW/XXXX/2024

Dated: 11.04.2024

April'2024

Design, Supply, Installation, Testing & Commissioning of 160 MW (AC) PV Power Plant at Moheshkhali.

April'2024

Section-6

Employer's Requirements (ERQ)

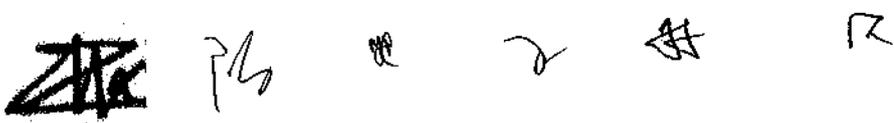


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1 Scope

1.1 EPC Specification

The scope of supply, installation, construction and commissioning of PV plant will include, but not limited, to the following main elements, subsystems, and facilities:

- PV power plant (including Solar PV panels, mounting structures, DC Combiner box with string monitoring, inverters, substation along with power transformers and associated switchgear and protection, control, safety, protection and monitoring equipment, etc.)
- PV Plant substation at plant location (it includes 132kV Indoor type GIS switchyard, 33/132kV step-up transformer with OLTC, meters, circuit breakers, disconnectors, surge arrestors, CT,PT, Insulators and other necessary protection and control equipment, Communication equipment. Generated power from the PV plant needs to be evacuated with 132kV overhead line).
- 33kV switchgear complete in all respect: SF6 Circuit breakers (In door) , Protection Control&Metering panel,CT, PT, isolator, etc. For incoming, outgoing, SVG (static VAR Generator) , auxiliary transformer, earthing transformer and PT.
- Construction of 07 (seven) KM 132KV double circuit evacuation line from 160MW(AC) Solar Power plant to Matarbari 132/33KV Grid Substation. 02 (two) KM double circuit line with 02 (two) bays on each side shall be constructed with four circuit tower architecture at Matarbari Grid Substation end for future expansion. However, only one double circuit shall be strung, tested and commissioned under this project. Moreover, approximately 170 meter 04 nos single circuit tower shall be erected and out of 04 single circuit 02 nos single circuit shall be strung, tested and commissioned under this project. The scope shall include, inter alia, stringing of 18.4 KM the second circuit on the existing 132 kV Maheskhali-Chakaria transmission line with 01 (one) bay each side and installation of OPGW.
- One(1) lot of complete 132kV GIS Switchyard Equipment System connected to Matarbari Grid Substation by OHL. It includes 132kV circuit breakers, disconnectors, surge arrestors, CT, PT, Insulators and other necessary protection and control equipment along with accessories. It also includes the necessary equipment and facilities for the extension bays of Matarbari Grid Substation and Chakoria Grid substation.
- All necessary extension/modification required for the interconnection facilities and communication facilities including Control&Protection System(i.e.PV Plant,Substation Automation/Control System, Transformer Protection,Line Protection,Fault Recorder, Busbar Protection with Breaker Failure Protection, etc.).
- All related connections between PV plant, 132kV delivery switchyard with associated MV&LV cables, switchgear, protection, control, metering and monitoring system.
- LV distribution panel
- Instrumentation, data acquisition, control and supervision
- SCADA system
- Installation of CCTV surveillance system from the project period.
- Security lighting system for the whole plant area especially in the peripheral areas.
- All Civil, mechanical, and electrical works
- Supply and construction of the fire protection system
- Oil water separator with sufficient capacity as per plant requirements
- Water supply system including water intake system, pre-treatment system (if necessary), water tanks for potable water and fire water, and necessary sanitary sewage treatment and discharge system, and ensures the discharge is up to standard.

- Earthing and lightning protection scheme for the power plant
- Land filling and land development, including the Gas Power Plant area
- For the other probable land filling and land development works outside of the PV and Gas Power Plant boundary according to the Owner's requirement, the Contractor shall gain the corresponding money according to the price in the table Schedule No.4.Civil, Installation and Other Services
- Construction of 4.5m wide (4m in width, with 2X 0.25m wide shoulder) internal maintenance roads
- Construction of 6m wide RCC + Asphalt Road (Main service road that connect the PV plant substation with the nearest or most favorable existing and concrete road)
- Construction of main control room, power distribution building and related living facilities
- Construction of Spare Parts Storage Room
- Construction of steel mesh security fence along the boundary for the whole plant.
- Overseas training for O&M personnel for twenty (20) man-month
- Automatic robot cleaning system
- Auxiliary transformers with accessories
- UPS Battery Emergency Power Supply (DC and uninterruptible power supply) for entire PV plant
- Tariff meters (main and spare)
- Fully equipment meteorological stations.
- Inspection of the major equipment as described in Employer's Requirement.
- All necessary pre-commissioning, commissioning, acceptance test, reliability test, performance test as described in the Section 6: Employer's requirement.
- Contractor also needs to do the following additional tasks (but not limited to) for the successful implementation of the project:
 - Assessment of the site
 - Development, detailed design, engineering (including equipment specifications), coordination of subcontractors, permitting, procurement manufacturing, factory testing, transport to site, erection, construction, commissioning and performance testing of the PV plant and other new installations
 - Obtain permission to connect electricity for construction, construct related facilities and bear the costs incurred.
 - Road works that in the view of the Contractor are necessary for the construction and operation of the PV plant
 - Works and services related to preparation, civil, mechanical, electrical, I&C and communication works including all required equipment for the execution of these works and services
 - Providing security on site as per insurance requirements and the security technical specifications of the Employer and as per all applicable codes and standards.
 - Maintenance of the PV plant for a period commencing upon the completion of Reliability Run and up to the lapse of two (2) years from the date thereof (Defect liability Period Warranty Period). During the Defect Liability Period of two (2) years, the Contractor shall supply all necessary personnel, equipment/spares, materials, at their own cost
 - Occupational health and safety for construction and operation of the plant
 - Environmental protection and soil and water conservation complying with local standards

The Contractor shall include in its scope all facilities and equipment necessary for the generation of power from the PV plant and all works and services including workshop and store equipment, special tools and handling equipment, spare parts, consumables, etc. necessary for complete, safe and reliable operation and

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preventive and corrective maintenance of the PV plant. Furthermore, the Contractor shall be responsible for the security at the site during the installation process up to OAC.

The work shall be performed according to the Good Industry Practice which means, at a particular time. Those practices, methods and acts as are in accordance with good standards of prudence applicable to the international electricity generation industry which would have been expected to accomplish the desired result at lowest reasonable cost consistent with reliability, safety and expedition. The scope includes also works not explicitly stated in the Employers Requirements or elsewhere in the Bidding Documents but which are reasonably required for the installation and operation of the PV plant according to Good Engineering Practice.

Reputable manufacturers shall manufacture new equipment, which shall be subject to Employer's review and approval. NO used, reconditioned or salvaged equipment or material will be allowed. All equipment used in connection with the Project shall be of proven design for the intended use of the equipment. As a general principle, the latest, commercially proven, most modern and up-to-date technologies will be selected and licensing terms agreed with the objective of maximizing value to the Employer.

The Plant shall be designed, manufactured, erected and configured in such a way that it will achieve high life expectancy, high availability and reliability with minimum power generation costs.

All parts of the Plant shall be suitable in every respect for continuous operation at maximum efficiency as well as part loads and minimum load, under consideration of the climatic condition specular to the site and environmental restrictions. Extreme weather conditions like cyclones are excluded from this requirement. But the Contractor must design the PV plant including all required structures and facilities in such a way that they withstand also extreme weather conditions according to the last version of the Bangladesh National Building Code (BNBC). Each PV Plant element or component shall be designed to withstand the design ambient conditions as stated under Section 6, Clause 2.1.

All PV Plant equipment and systems shall be built according to internationally recognized standards and shall comply with all the applicable national codes and statutory requirements as stated under Section 6 Clause 2.3.8

The Contractor shall apply a well-established component classification and identification system. The international SI system of units shall be used for design, drawings, diagrams, instruments, etc.

The Plant shall be designed to achieve a high level of reliability through component redundancy, quality construction implementation, quality equipment selection, and maintainability and operability. The facility shall be designed for safe continuous operation including the capability for unforeseen shutdowns.

The Contractor shall provide first aid sets at all permanent working locations, like offices, storages and workbenches and gatehouse.

1.2 Engineering Design

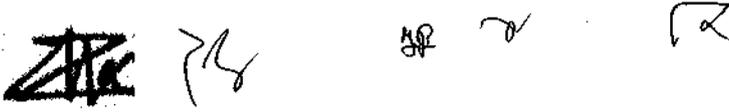
The Contractor shall develop the PV plant's detail engineering design in compliance with this Specifications, Employer's review and approval and following best industry practices. The Contractor shall prepare the project's documentation that shall include, among others, the engineering, preparation and delivery program of the engineering, guaranteed data, essential diagrams, general arrangements, design criteria and main equipment specifications.

The design of the equipment and systems of the Plant shall be based on achieving the performance guarantees as described in Section 6, Clause 2.4.6 and its corresponding test procedures Section 6, Clause 2.4.4 of this bidding document. The Contractor shall apply for and be responsible for successfully passing all required approvals and certifications of the authorities, the government and the related authorities and organizations.

1.3 Preparatory Works

Prior to the start of construction and installation, the preparatory works shall be performed in advance so that the erection of realized as planned. At his sole responsibility the Contractor shall conduct and review, limited, to the following preparatory works:

- collection of general meteorological data
- conduction of own geotechnical studies
- conduction of backfill studies including compaction



- conduction of logistics and transportation studies for time of construction
- conduction of a cartographic surveys for the exact location of boundaries and the elevation above sea level
- the Contractor is required to prepare the Environmental Management Plan
- obtaining all required permits such as building permit, etc. in the name of the Employer, furthermore all certificates and acceptances of the authorities and related organizations
- The Contractor is required to prepare Occupational Health and Safety Plans, one for the site and construction purpose, one for the operational purpose
- data collection regarding interface points
- due diligence of all applicable aspects
- site preparation including land filling, compaction of soil, with imported fill and grading of the entire area of the site to the required levels and slopes, as required, in accordance with the building plan
- provision of temporary laydown areas, warehouses, workshops, vehicles, equipment etc. All as necessary for the construction phase
- disposal of demolition materials according to local environmental guidelines
- provision of precast yard as necessary
- provision of temporary firefighting and alarm system
- provision of temporary site drainage, storm water and sanitary drainage all as necessary for the site
- disposal of sewage, as necessary
- provision of temporary housing compound and camp facilities
- provision of temporary water, power ,communication and network supply
- provision of temporary roads, as required
- provision of temporary site fencing including gates
- provision of first aid, site safety and security for the construction phase as per insurance requirements
- provision of temporary offices for the Employer and Employer's Engineer
- provision of temporary furnished offices for the Contractor
- provision of temporary dining room and equipped kitchen
- provision of temporary school room for safety training
- provision of temporary reinforced security rooms according to the authorities requirements
- provision of temporary spill containment pallets
- site services as required for the construction and commissioning of the Plant such as electricity supply, potable water, instrument and service air, fuel supply, telecommunication etc.
- provisions of at least 6 webcams for site and progress supervision from start of construction including GPRS communication system, wide angle, tilt and rotation capability, HD quality and remote control feature at light poles,as well as appropriate record and storage capabilities.The storage time requirement for camera records is 3 months.
- 2 Specification
- 2.1 Site conditions

The Contractor is responsible for its own investigations to establish sufficient and accurate information for the design of the Plant. He shall visit the proposed site and shall ascertain the nature and location thereof and all conditions which may affect design/layout of the PV Plant and the project costs.

The Contractor shall make its own assessment of any and all of the information provided in this bidding document and collect own information. Neither the Employer, nor any governmental institutions or other entity nor any representative or advisors to the government is responsible for the accuracy or completeness of any such information.

The Employer shall not be liable for any on site System during construction. The Contractor shall have its own on-site project management office and site warehouse for material storage with required security. Maintaining the hygiene, the Contractor shall have adequate mobile toilets at multiple locations within the site.

2.1.1 Site Description

The project will be in the block 1 and block 2 on the north of the energy island park which is on the south bank of Kuhelia River, Maheshkhali Upazila, Cox’s Bazar, Chattogram. The station is located on the west side of Z1004 road, about 80km from Chattogram in the northwest and 23km from Cox’s Bazar Airport in the southeast. The geomorphic origin of the proposed plant site is coastal plain, rice field in the east, shrimp pond in the west, open terrain, flat terrain, and generally 0.71-1.44m above ground.

The project boundary coordinates are shown in the Table 2-1.

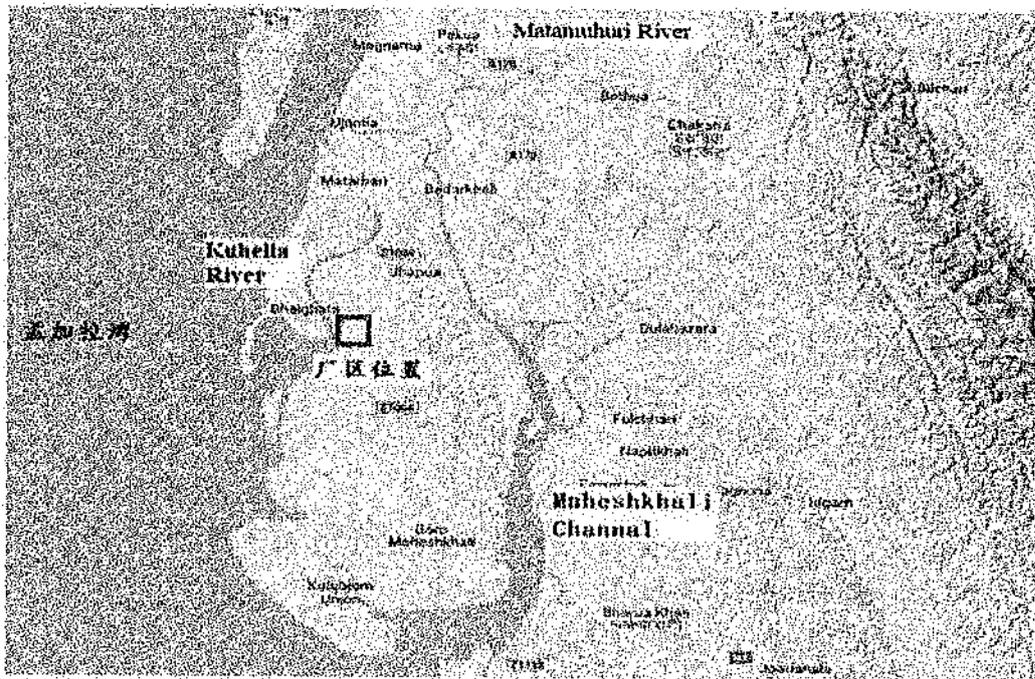
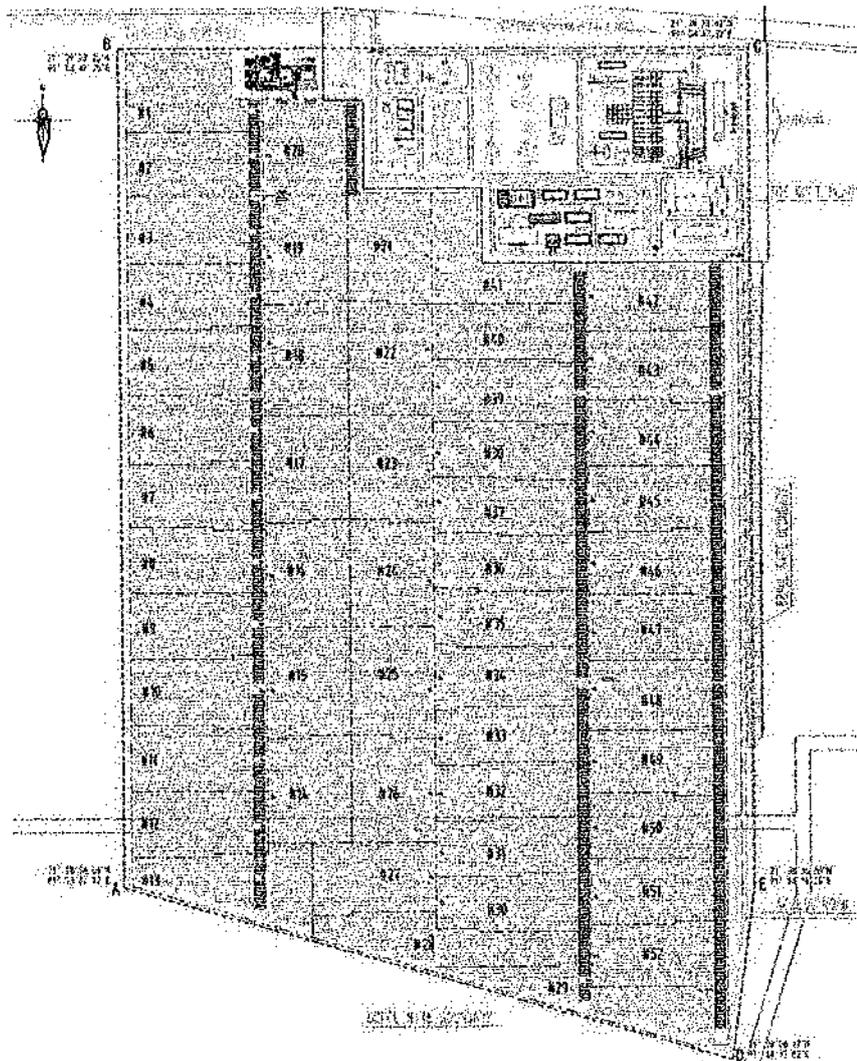


Fig. 2-1 Site Location

Table 2-1 The project boundary coordinates

POINTS	COORDINATES
A	21°38'36.06"N, 91°53'42.12"E
B	21°39'23.25"N, 91°53'41.75"E
C	21°39'23.42"N, 91°54'17.92"E
D	21°38'26.47"N, 91°54'17.02"E
E	21°38'36.30"N, 91°54'18.28"E

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2.1.2 Solar irradiation

The irradiation data of the site were obtained from the Solargis database, and other data such as temperature and humidity were obtained from the Meteornorm V8.0 database.

Table 2-2 Monthly Meteorological Conditions

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
GHI	135	152	181	184	171	133	143	146	144	144	143	136	1810
Ta	21	23.9	26.8	28.7	29.2	28.8	28.3	28.5	28.7	28.2	25.7	22.3	26.7
Ta min	12.8	15.6	20.3	22.3	23.4	23.4	23.6	24.4	24.3	23	18.3	14	12.8
Ta max	29.6	32.2	34.7	34.9	34.4	33.9	35.5	33.8	33.3	33.8	32.8	30.3	35.5
RH	65	61	66	73	77	81	83	82	81	77	70	69	74
RR	8	12	62	131	503	803	1094	648	449	278	54	4	4046
RD	0.6	0.9	2.8	7.3	18.1	25.5	28.3	27.4	24.8	15.1	2.7	1	154.5

GHI: Irradiation of global radiation horizontal, kWh/m².

Ta: Air temperature, °C

Ta min: 10 y minimum, °C

Ta max: 10 y maximum, °C

ZHC *75* *287* *R*

RH: Relative humidity, %
 RR: Precipitation, mm
 RD: Days with precipitation, days

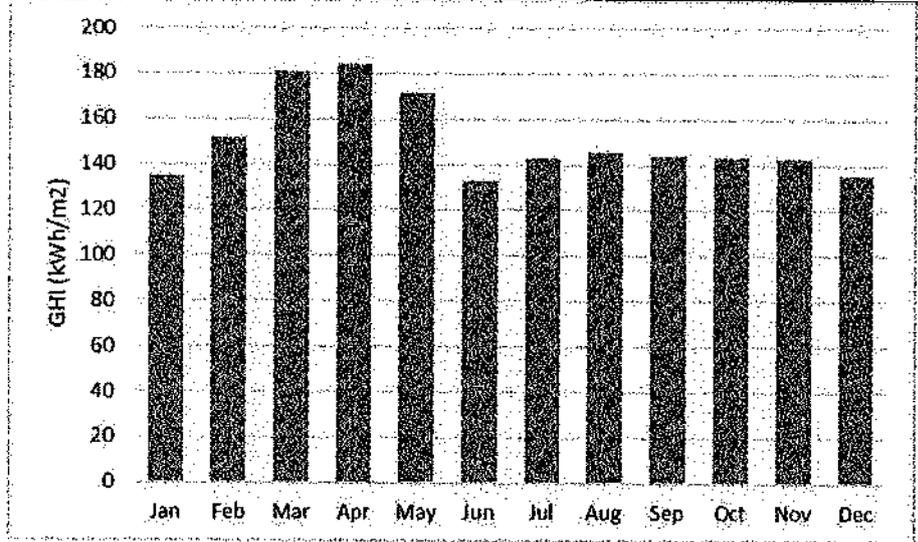


Figure 2-3 Monthly GHI distribution

There are currently no measured solar radiation data at the site. The above information is for reference only, and the contractor can select appropriate solar radiation data and meteorological parameters as input conditions according to the information available.

2.1.3 Wind Condition

According to BNBC (Bangladesh National Building Code, 2020), Cox's Bazar and Kutubdia are the areas closer to the plant site, and the basic wind speed values are both 80m/s. Therefore, the basic wind speed of the site is taken as 80m/s.

2.1.4 Seismic condition

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In the case of not taking into account the wave-dissipating influence of mangroves, the design wave height on the west side of the photovoltaic field shall be considered as 4.50m; considering the wave-dissipating influence of mangroves, the design wave height on the west side of the photovoltaic field shall be considered as 2.13m.

In the execution stage of the project, the contractor shall carry out the hydrology wave study, which will be as the input data for the PV project design.

2.2 PV Plant Design Concept

The PV Plant shall be built with approximated capacity of 192.78MWp (DC)/160 MW(AC) where AC capacity will be measured at 132kV high voltage side of step up-transformer at PV plant substation.

The PV module shall be monocrystalline silicon, bifacial module with nominal peak power at STC approximated 550Wp. The Contractor may provide PV module with higher nominal peak power on his own experience and recommendation.

The PV module mounting frames and structures shall be built with fixed tilt angle. The tilt angel is recommended for 15° and South-facing orientation. In order to get higher power generation and PR, the contractor can optimize the design, but it shall be confirmed by the employer.

The inverter shall be central type. Each string will connect to one DC combiner box and DC combiner box will connect to the central inverter. A total of 52 central inverters set with minimum capacity of 3125kW@50°C shall be installed to collect the energy produced by the solar array. The PV power plant is divided into 52 PV sub-arrays, and each sub-array is equipped with a 0.6/33kV Combined transformer with capacity of greater than or equal to 3150kVA@50 °C . The Combined transformer will be grouped and connected to 33kV switchgear busbar at 132kV PV substation.

Two 100MVA 33/132kV main transformers are provided in 132kV PV substation. Armored handcart-type HV switch cabinet shall be adopted for 33kV switchgear. It is planned to install SVG(Tentatively 4 sets per set ± 32500kVar) on 33kV busbar to ensure that the power factor of the 132kV outgoing line remains between 0.85 and 1.0.

The short-circuit current and equipment selection shall refer to the following table:

Equipment	Short-Circuit Current	Rated Current
132kV	40kA/1s	1250A
33kV	31.5kA/1s	3150A
0.6kV	50kA/1s	-

The 132kV outgoing station will be connected to the Matarbari substation via an overhead line. For the grid connection detail, refer to Section 2.3.8.1-Grid Connection.

This project shall be use the ACRS(Automatic cleaning robot system).i.The product weight is within 70KG; ii.Cleaning speed: 8-20m/min iii.The height difference between adjacent components shall not be greater than 20mm ;iv.Wind resistance rating shall not be greater than 9 ;v.Waterproof and dustproof grade is not less than IP65; vi.The design life cycle shall not be less than 10 years; vii.Charge and discharge times: the capacity of 1000 cycles is not less than 70% sanitary parts of best quality in prior approval by the Employer

2.3 General Specifications

2.3.1 Permits, Licenses And Consents

It is the sole responsibility of the Contractor to identify, to obtain, to complete, and maintain any permits and any other consent, licenses and approvals that are required for the Plant as per all applicable codes and standards and local regulations, Employer will support the Contractor to collect those. The time line required to conduct all necessary associated studies or checks on site including checking of reinforcement, sufficient concrete covers, anchors and embedded parts must be included into each Contractor's work plan. Employer

will co-ordinate with the Contractor in identifying, applying, and processing such permits, consents, licenses and approvals.

2.3.2 Quality Assurance and Control

During project execution, the Contractor will be required to develop, implement and maintain a project specific quality plan covering all aspects of the project.

The Contractor shall provide a quality assurance manual applicable to the design, procurement, construction, commissioning and testing of the Plant and evidence of accreditation to a national or international assurance standard equal to ISO 9001.

2.3.3 Health, Safety and Environmental Requirements

The Contractor is requested to provide a sound-working environment to all employees involved in the design, construction and operation of the Plant. This includes the consideration of but not limited to:

- all applicable national and international laws, guidelines and standards
- all applicable national and international codes and standards with respect to Occupational Health and Safety and Environmental Protection.

The Contractor has to ensure that the following HSE objectives are met during the plant design, construction period:

- zero accidents and injuries with respect to all involved workers
- zero harm to workers, the public and the environment

The Contractor shall prepare and implement a comprehensive Health, Safety and Environmental (HSE) Plan and associated working instructions and procedures (to be included in the HSE Plan as mentioned below) that will govern Contractor’s actions at all times during the design preparation and construction of the Project as well as during the operating phase of the Plant.

The HSE Plan must include the following content and objectives as a minimum:

- project policy statement
- roles and responsibilities
- site regulation, incl. e.g. housekeeping, barricades, excavations, tools and equipment, electrical work, ladders and scaffolds etc.
- risk management & hazard identification
- HSE Training
- HSE management of subcontractors
- Work permit system
- personnel protective equipment
- inspection & auditing
- HSE meetings
- incident investigation & reporting
- site security
- medical care & first aid.

The HSE Plan shall include environmental mitigation and monitoring measures as per the Environmental Management Plan as part of the ESIA to ensure Contractor's commitment to the highest standard of environmental protection at the construction site and during all phase of the construction activities.

The Contractor will be required to design, construct and commission the Plant in accordance with the applicable HSE laws and standards, and in compliance with an overall, comprehensive and pro-active Health, Safety and Environmental Plan, in terms of which the Contractor will incorporate into the design and construction of the Plant such equipment, processes and facilities, as will facilitate the operation of the Plant, in accordance with environmentally sound and sustainable policies, practices and procedures.

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The Contractor shall develop and implement an emergency response plan outlining all necessary measures and communication procedures in case of emergency situations.

2.3.4 Packing and Transport identification

All parts of the Plant and Equipment shall be well packed and protected against loss or damage during the transport by sea and over land and whilst in storage under adverse climatic conditions. All packing shall be performed in such a way that overturning of the packages will not damage the equipment. Dimensions of packages, crates, etc., shall be suitable for road transport. Instruction for handling shall be clearly marked on all parts, packages and crates.

All parts, packages and crates shall be adequately marked in order to enable identification. Each item contained in a package shall be clearly identified on the packing list by its description and part number and assembly drawing reference, and each item shall be marked or labeled to correspond with the packing list.

The cost of all equipment needed for temporary fixing and supporting of various parts of the PV Plant and the various packages to crane hooks, etc., during handling, transport and storage and the cost of load distribution beams, etc., where they form part of the packing or crates, shall be included in the Bid Price.

The Contractor shall be entirely responsible for all packing and any loss or damage shall be replenished/ fixed by the Contractor and, except where otherwise provided, at the Contractor's own expense.

Any transshipment of materials and equipment through countries adjacent to Bangladesh shall be the Contractor's responsibility. Any cost(s) associated with transshipment of materials and equipment shall be deemed to be included in the Contract Price.

Identification, reinforcement or reconstruction of roads and bridges for access to the site and transportation of equipment and materials shall be the responsibility of the Contractor. Any costs associated with identification, reinforcement and upgrading of roads and bridges shall be deemed to be included in the offered Price.

2.3.5 Material Properties

- Materials selected by the Contractor shall be proven adequate and sufficient for the complete term of the Project.
- The Contractor shall carefully consider all corrosion and erosion possibilities subject to the environment of the Site and nearby facilities.
- All non-metallic materials in contact with water shall be proven, tested and certified as suitable for its purpose by an Bangladesh recognized independent testing authority.
- Metallic and non-metallic materials shall be UV resistant and stand high temperature operation regimes over the whole Plant life time; and where materials are specified in any part of the Employers Requirements, those materials are to be considered as minimum requirement.

2.3.5.1 Corrosion Protection

The Contractor shall be aware of and take into account the corrosion problems to be encountered on site due to the severe weather conditions, especially with equipment installed outdoors.

This shall include as well the correct choice including of but not limited to any fasteners, bolts, dowels, anchors. Also contact corrosion and electron chemical corrosion shall be avoided by selecting only suitable materials and coatings or galvanization.

The Contractor shall provide with their Design Basis the civil design criteria they intends to follow, in which details regarding his proposed methods of corrosion protection for reinforced concrete and steel structures are given and procedures described.

Furthermore, the Contractor shall submit about their proposed concrete surface and metal surface protection systems. Detailed specifications are given in the following where required.

2.3.5.2 Reinforced Concrete

The guidance for a suitable concrete design, it is recommended that local or Chinese GB codes and standards shall be used for the structural design.



Prior to detail engineering, the Contractor is required to describe their minimum requirements for concrete covers and proposed method of concrete production considering the local conditions. The quality control system on site to guarantee the quality shall be described in detail.

Special care shall be taken for concrete production under hot weather conditions (e.g. Suitable mix design, water-cement factor, provision of salt-free water for the admixture, concrete additives, cooling of aggregates and water, use of vibrators, curing methods, cooling of poured concrete and control of heat of hydration within the foundation and respective controls etc.). Explanations shall be given with regard to crack-free concrete design, in particular concerning groundwater structure and monolithic elements, if applicable.

All applicable codes and standards shall be respected especially where water protection, retention of oil-polluted water and related threats may occur such as in transformer basins.

Concrete surfaces subject to subsequent coating or painting shall be built and cured suitably.

Horizontal surfaces exposed to exterior environment shall be designed with a slope to improve the drainage of rainwater.

Grouting shall be done with approved shrink-free grouting material in coordination with the construction above.

2.3.5.3 Steel Structures

Steel work shall be designed to Chinese GB standards and meet the BNBC requirement, and shall be fit for the purpose in each case to avoid corrosion, which might reduce the technical lifetime of the steel work.

Applicability of selected materials for structural steel works is subject to the design review process during detailed design stage.

For the main metal and steel structures in the area of the PV plant adequate hot-dip galvanized coating would be accepted. Galleries, handrails, cable trays, ladders and other miscellaneous steel work are accepted to be hot-dipped galvanized.

Structural steel work shall be coated with minimum three (3) workshop coats (prime coat, intermediate coat and final coat) and a touch-up / repair on site after erection where necessary. The minimum required thickness of zinc coating for hot-dip galvanized steel elements depends on the thickness of the element. The minimum coating shall be specified during detailed design for a minimum lifetime of 25 years in use.

The embedded items (anchor bolts, fixing elements etc.) for outside and inside conditions subject to corrosive climate and chemical attack, etc. shall be of galvanized steel or as required.

The embedded items for inside conditions (no corrosive climate) shall be hot-dipped galvanized and shall be adequately painted in addition.

2.3.5.4 Insulation

Thermal and acoustic insulation of buildings, structures and equipment shall be provided as appropriate to conserve energy and to minimize the noise impact, provide personnel protection, provide protection against freeze or overheating, prevent excessive air conditioning, prevent condensation, prevent fire or smoke spreading and attenuate noise.

2.3.5.5 Water proofing

The Contractor shall suitably take care for water proofing as per all applicable codes and standards. The same shall be true for damp proofing or vapor proofing where required.

Where necessary, the above mentioned shall be considered for underground structures or foundations.

Where oil-proof coatings or coatings to preserve from contamination of the ground water are required, the Contractor shall provide suitable coating systems. Included shall be the documentation of each of the products for inspection and repair works at a later point of time.

2.3.5.6 Site office, Furniture and Equipment

The Contractor shall install, make available to the Employer and the Employer’s engineer and maintain the Employer’s local on-site office. The office shall accommodate at least ten (10) working stations, one conference room, one meeting room, one kitchen with dining facilities, toilets. The office will have all modern facilities including all furniture, fixture, table, chair, almirah, file cabinet, printers and photocopiers, internet, facsimile, projector, whiteboard, etc. Each room in the rest house must be equipped with all kinds of necessary furniture (i.e. bed, dressing table, wardrobe/ cabinet, 2 seater sofa, 1 TV, reading table with chair etc) and the common dining & drawing room/ living space must be furnished

with proper arrangements (15 persons dining table set with chair, refrigerator & freezer, min. 55inch TV in the drawing/ living space). Furthermore, the rest house shall have to be furnished with some indoor sports arrangements (i.e Table tennis board, Billiard Board etc). The Contractor shall supply atleast 2 vehicles during the mobilization and site preparation works. The Contractor shall connect all needed services (electricity, drinking water, wastewater discharge, telecommunications, etc.) to these offices.

2.3.5.7 Vehicle / Car

The Contractor shall have to supply the following car/ vehicle for the transportation of the officers and employees:

Van/ Mini Van – 01 No

Body Type: Van/ Mini Van
Seating Capacity: 7 Person,
Displacement: 1800 CC,
Fuel Type: Hybrid-Petrol/ Octane,
Brand: Toyota/ Mitsubishi/ Nissan/ Hyundai/ equivalent,

SUV – 02 Nos

Body Type: SUV
Seating Capacity: 5 Person
Safety Feature: 5star
Displacement: 1800 CC
Fuel Type: Hybrid
Brand: Toyota/ Mitsubishi/ Nissan/ Hyundai/ equivalent,

Van (Microbus) – 02 Nos

Body Type: Van (Microbus)
Seating Capacity: Min. 11 Person,
Displacement: 2500 CC,
Fuel Type: Petrol/ Octane,
Brand: Toyota/ Mitsubishi/ Nissan/ Hyundai/ equivalent,

Double Cabin Pickup – 02 Nos

Body Type: Double Cabin Pickup
Seating Capacity: 5 Person,
Displacement: 2400 CC,
Fuel Type: Petrol/ Octane/ Diesel,
Brand: Toyota/ Mitsubishi/ Nissan/ Hyundai/ equivalent

Speed Boat: (01 No)

Type: Passenger boat
Motor type: outboard
Cruising speed : 28 kt
Size(m):. ≥8.15*2.2*1.1 m
Passenger: ≥12 person
Power: ≥ 200hp, outboard engine propulsion, gasoline
Power Brand: YAMAHA, SUZUKI, MERCURY, EVINRUDE
Speed: ≥45km/h
Boat Body Material: glass fiber reinforced plastics
Minimum Endurance: ≥4h

2.3.6 Environmental Management Requirements

It must be the understanding of Contractor to avoid any environmental damage and/or concerns to the environment during any phase of the project.

Therefore, the Contractor shall provide, operate and maintain the Plant to meet all applicable national and international environmental regulations, environmental standards and stipulations. The Contractor shall



demonstrate during the design and construction phase and during the performance tests respectively operation phase that the Plant is able to comply with all applicable

environmental regulations and standards. Applicable standards for environmental protection must be fulfilled without any restrictions. This applies in particular but not limited to:

- water pollution limit values and standards
- limit values for environmental noise
- health and safety of construction workers and permanent staff.

2.3.7 Codes and Standards

The Contractor shall ensure that the engineering, design, construction, testing, etc. of all Plant components, including all auxiliary facilities and systems, are according to internationally recognized standards and codes in their latest edition as well as the Bangladesh standards.

The latest editions of the standards, codes and recommendations and directives including the national annexes issued by the following organizations shall apply for the design, construction, testing and commissioning of the Project.

2.3.7.1 International standards

- EC European Standards
- ISO International Standardization Organization
- IEC International Electrotechnical Commission

2.3.7.2 National standards

- ANSI American National Standards Institute
- BNBC Bangladesh National Building Code
- BS Bangladesh Standards
- GB(including GB,NB,DL , JGJ,JTG NB/T series) Chinese Codes and Standards
- NFPA National Fire Protection Association standards

Application of subsequent addenda and code cases published after the Contract award is subject to agreement between Employer and the Contractor.

The Contractor shall draw Employer's attention to any conflict between the requirements of this document and Employer's references. Should the requirements of this document conflict with the requirements of the codes and standards references herein or with the applicable law, standards, local regulations and Employer's design specifications, then the more stringent requirements shall apply. Should there be any difference of opinion with regard to the interpretation of requirements, the Employer shall instruct the Contractor as to the requirements and the Contractor shall, at its cost, comply with that instruction.

For the design and construction of the buildings, structures or foundations the following codes and standards including the related national annexes shall be applied additionally:

- Bangladesh Standards BS
- International Building Code IBC
- European Standards EN and EC
- American Association of State of Highway and Transportation Officials AASHTO
- American Concrete Institute ACI
- American Institute of Steel Construction, Inc. AISC

- American National Standards Institute, Inc. ANSI
- American Society for Testing and Materials ASTM
- American Society of Civil Engineers ASCE
- American Society of Mechanical Engineers ASME
- American Welding Society AWS
- Chinese Standards GB(including GB,NB,DL,JGJ,JTG NB/T series)

For all structures and structural components, buildings, basins, base plates and foundations an appropriate design according the above-mentioned specifications has to be elaborated and presented.

The design report shall include among other items the following minimum descriptions:

- Introduction and structural description
- Detailed drawings of structures and foundations material properties
- Used normative and codes
- Load assumptions, safety factors and combination coefficients analysis and design criteria
- Technical references
- Structural calculations
- Design results
- Information about the design software
- connection design.

For the complete structure and structural components, buildings, basins, base plates and foundations the design method "Load Factor Design Method (LFD)" shall be used.

Prior to construction, proper design drawings for all structures and structural components, buildings, basins, base plates and foundations have to be presented. The drawings shall indicate material properties, sizes and dimensions of all elements, location of installation, constructing procedures, technical specifications, numbering system of elements, etc. Each drawing shall be equipped with a general plant overview indicating the location of the displayed element. Clear information shall be given by appropriate details. All drawings have to be in scale, for overview drawings, the scale shall be 1:200, 1:100 or 1:50, for detailed drawings, the scale shall be 1:25,1:20,1:10 or 1:5.

The Contractor is required to design, construct the PV Plant in adherence to the Electricity Distribution Code released by the Bangladesh Energy Regulatory Commission in November 2012.

Amongst others, the following international standards shall apply for the installation, testing, and operation of the PV Plant (not limited to):

General:

- IEC 60364 (all parts), Low-voltage electrical installations
- IEC 61936-1, Power installations exceeding 1 kV a.c. - Part 1: Common rules
- IEC 60071, Insulation co-ordination - Part 1: Definitions, principles, and rules
- IEC 60068, Environmental testing. Part 1: General and guidance

PV Installation:

- IEC 60364-7-712:2002. Electrical installations of buildings - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
- EN 50521:2008 Connectors for PV systems

- IEC 60228, 60364-1, 60332-1-2, 60754-1 and -2, 61034, TOV approval 2Pfg1169: cable
- design and wiring for the electrical infrastructure and connection infrastructure (DC cables should be solar cables)
- IEC 62109-1 and IEC 62109-2: Safety of power converters for use in photovoltaic power systems - Part 1: General requirements & Part 2: Particular requirements for inverters

Commissioning and Documentation:

- IEC 603646, Low-voltage electrical installations - Part 6: Verification
- IEC 62446, Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection

Power Transformers:

- IEC 60076, Power Transformers
- IEC 60376, Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
- GB/T 12706.3-2008 Power cables with extruded insulation and their accessories for rated voltages from 1kV (Um=1.2kV) up to 35kV (Um=40.5kV) - Part 3: Cables for rated voltage of 35kV (Um=40.5kV) or IEC60502-2

LV System:

- IEC 61439, Low-voltage switchgear and control gear assemblies
- IEC 60439, Low-voltage switchgear and control gear assemblies
- IEC 60947, Low-voltage switchgear and control gear

Earthing & Lightning Protection:

- IEC 60364 (441) Low-voltage electrical installations: Protection for safety Protection against electric shock
- IEC 60364 (5-54) Low-voltage electrical installations: Selection and erection of electrical equipment - Earthing arrangements and protective conductors
- IEC 61936-1 Power installations exceeding 1kV A.C. - Common rules
- EN 50522 Earthing of power installations exceeding 1kV A.C.
- IEC 60364-7-717 Low-voltage electrical installations: Requirements for special installations or locations - Mobile or transportable units
- IEC 62305 (all parts), Protection against lightning
- IEC 60099 Surge arresters

EMC:

- IEC 61000, Electromagnetic compatibility (EMC)

Buildings and housings, inverter protection:

- IEC 60721-3-3 Section 3: Classification of environmental conditions (stationary use at weather protected locations)
- IEC 60721-3-4 Section 4: Classification of environmental conditions (stationary use in non-weather protected locations)

Including all other reference norms and standards mentioned above and all other applicable norms (normative references).

Where construction and maintenance rules or guidelines of the manufacturers of the products or systems are available, the Contractor shall follow these instructions as well. If special training are required for execution the job, the Contractor shall make sure his staff has successfully received the respective training including the documentation thereof.

2.3.8 Interfaces

"Interfaces" are the connections and physical tie-in points between the PV Plant and 132kV grid connection I&C and communication facilities.

The interfaces between Employer and the scope of work of Contractor are outlined in the single line diagram (SLD) attached in Annex B-04.

The Contractor shall include with their Bid a complete and detailed description of the interfaces. The Contractor is obliged to coordinate the interfaces to other facilities / with other parties in cooperation with the respective counterpart.

2.3.8.1 Grid Connection

The contractor shall design, supply and build of 07 (seven) KM 132KV double circuit evacuation line from 160MW(AC) Solar Power plant to Matarbari 132/33KV Grid Substation. 02 (two) KM double circuit line with 02 (two) bays on each side shall be constructed with four circuit tower architecture at Matarbari Grid Substation end for future expansion. However, only one double circuit shall be strung, tested and commissioned under this project. Moreover, approximately 170 meter 04 nos single circuit tower shall be erected and out of 04 single circuit 02 nos single circuit shall be strung, tested and commissioned under this project. The scope shall include, inter alia, stringing of 18.4 KM the second circuit on the existing 132 kV Maheskhali-Chakaria transmission line with 01 (one) bay each side and installation of OPGW.

2.3.8.2 Instrumentation and control

The Contractor shall be responsible for the coordination with Employer for the proper consideration and realization of all instrumentation and control aspects being relevant for the exchange of required data. The necessary equipment shall be in line with the requirements of Section 6, Clause 2.4.3 and the additional indications provided in the Annexes mentioned above.

2.3.8.3 Communication Facilities

The Contractor shall be responsible for the connection of the communication facilities of the PV plant to the available local communication systems. For the interconnection the requirements in Section 6, Clause 2.4.3.7 shall be considered.

2.3.10 Requirements of Security Personnel

Contractor shall construct facilities for the PV Plant to operate safely.

2.4 Technical specifications

2.4.1 Electrical Requirements

2.4.1.1 PV Power Plant

Mono-Crystalline PV modules will be installed on a metallic mounting structure on which they will be placed in several rows upon each other depending on the module and mounting structure dimensions.

The string length of modules connected in series depends on the voltage of single modules in order to not surpass open circuit string voltages of 1,500 V under extreme environmental conditions (low temperatures and high irradiation). The PV module strings will then be connected to three-phase central inverters. Appropriate cables will then evacuate the AC power to the PV transformer stations.

One PV transformer station comprises of LV switchgear and auxiliary service, LV/LV auxiliary transformer, LV/33kV transformers and 33kV switchgear.

PV transformer station building shall comprise of room for LV switchgear, LV/LV auxiliary transformer and auxiliary service panel including UPS room for 33 kV switchgear.

The LV/33 kV transformers shall be suitable for installation outdoors.

33 kV switchgear located in PV transformer station consist of several outgoing and one incoming feeder according to the SLD. The incoming feeder from the LV/33 KV transformer consists of circuit breaker and an earthing switch. The outgoing feeder for the connection between PV transformer stations and substation consists of switch-disconnector and an earthing switch. It is required to use circuit breakers for breaking operation on the high-voltage side of transformers with a capacity of 3000kVA or above.



The PV transformer stations shall also include the following components and requirements:

- communication panels
- connection to the I&C System
- auxiliary loads electric board
- earthing and lightning protection.

The transformer station LV switchgear room shall be prepared to allocate AC load breakers, low voltage auxiliary load distribution board, emergency lighting, fire protection equipment, first aid set, and auxiliary transformer energy consumption. Fire detection and firefighting systems shall be in accordance with local regulations if any, otherwise it shall be implemented in accordance with international regulations and passed local fire-protection acceptance.

2.4.1.1.1 PV modules

The PV Plant will be deployed by implementing bifacial mono-crystalline silicon. PV modules shall be selected according to the following minimum requirements:

- the fulfillment of the following IEC standards including certificates:

IEC 61215	Mono-Crystalline silicon terrestrial photovoltaic (PV) modules-Design qualification and type approval
IEC 61730	Photovoltaic (PV) module safety qualification
IEC 61701	Salt mist corrosion testing of photovoltaic (PV) modules
PID/IEC 62804 or similar standard	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation

- Product and workmanship warranty of at least 10 years
- power output warranty: based on a linear degradation for 20 years of operation as follows: first year degradation: $\leq 2\%$
- from year two through twenty, yearly degradation: $\leq 0.45\%$
- After the power output warranty starts, it ends in the 20th year and drops to 89.45%
- module must resist ambient conditions in Section 6, Clause of 2.1
- PV cell rank: Class A
- Minimum module efficiency $\geq 21\%$
- PV module selected shall have positive tolerance (-0/+ and as high as possible)
- Modules shall not require any positive or negative grounding.
- PV module models selected should have been installed in other operating PV plants within the last one years and with a substantial aggregate installed capacity.
- PV module selected should have been installed and successfully operated (reference) in other PV plants under similar climatic conditions.
- temperature coefficient rated power of $-0.45\%/^{\circ}\text{C}$ or lower (e.g. $-0.44\%/^{\circ}\text{C}$ is defined as lower), and
- Potential Induced Degradation (PID) resistance and valid evidence/ certificate from independent third parties.
- The IV-curve has to be determined by third-party IEC accredited laboratory (e.g., TUV Rhineland, TUV Sud, TUV Nord, ZSW, JRC, etc.) at standard test conditions (STC) in accordance with IEC 60904-3.
- The PV module shall be bifacial mono crystalline with dual glass. The minimum thickness of the Front Glass 2.0mm with Anti-Reflection Coating and rear glass shall be minimum 2.0mm Heat Strengthened Glass.

- All the modules shall be equipped with IP67 or higher protection level junction box and appropriately sized output power cable of symmetric length with twist locking connectors of a well-known manufacturer.
- In order to minimize power loss due to partial shading on modules, all modules shall be equipped with bypass diodes.
- Modules shall be capable of withstanding a wind pressure of 2400Pa or the maximum recorded local wind loading, whichever is greater.
- Modules may be subject to high intensity hail storms or cyclones, thus appropriate measures should be taken for selecting glass.
- Module frames shall be corrosion resistant and shall have adequate holes for mounting, water drain and connecting ground conductor. All modules shall be appropriately grounded. Module structure shall be suitable for automatic robot cleaning systems.

Thereby a solar simulator (flasher) class AAA has to be used and to be mentioned in the report. Its spectrum has to be tested and calibrated on regular basis. The calibration of the solar simulator has to be performed with a stabilized cell with WPVS (World Photovoltaic Standard) cell format. Calibration date and institute of cell and solar simulator have to be mentioned on the report. The measuring system error referring to the maximum power has to be $\leq 3\%$. The mismatch correction value for PV module and the solar simulator mentioned above has to be mentioned. Temperature coefficients have to be mentioned. Measure and P_{mpp} , V_{oc} , J_{sc} as well as its relative error and repeatability have to be mentioned.

Pass criteria: the output power of the modules has to be within the specifications of the module label. Number of modules to be tested: 100 units. Employer or their representatives will randomly choose PV modules.

Ten (10) units shall be tested based on the testing conditions for PID as mentioned above Employer or their representatives will randomly choose the PV modules for testing.

Pass criteria: the output power at STC of 80% of the tested modules shall not decrease more than 5% of the initial modules output power before the testing in the climatic chamber at the above-mentioned conditions. The output power measurement results before and after climatic chamber PID tests of the remaining 20% of the modules should not decrease more than 10% of the initial output power. Testing during FAT or Independent Third-Party Agency Testing. Independent tests shall be performed to guarantee high quality of PV modules. The number of photovoltaic modules for non-destructive tests, tested by an accredited independent third party shall be at least ten (10) modules per batch. The modules shall be selected according to the instructions of the Employer/Employer's Engineer from different delivery lots. The independent tests shall include as a minimum the following measurements and shall be performed in an accredited independent laboratory.

- a. Electroluminescence and PID Testing
- b. Power at STC (Flash Test)
- c. Irradiation performance (I-V Curve)
- d. Temperature coefficient
- e. Bypass Diode Test
- f. Insulation Test, Low Irradiance Test, Wet Leakage

PV Module Cleaning System: An automatic robotic arm type cleaning system shall be provided. The proposed system shall comply with PV Module manufacturer requirements and shall not hamper generation in any way. For wet cleaning, chemicals used (if any) shall comply with all prevailing environmental standards and guidelines.

- i. The product weight is within 70KG
- ii. Cleaning speed: 8-20m/min
- iii. The height difference between adjacent components shall not be greater than 20mm
- iv. Wind resistance rating shall not be greater than 9
- v. Waterproof and dustproof grade is not less than IP65;
- vi. The design life cycle shall not be less than 10 years;



vii. Charge and discharge times: the capacity of 1000 cycles are not less than 70%

PV String combiner / Monitoring Elements:

- The Solar array shall be configured in multiple numbers of sub-arrays, providing optimum DC power to auditable number of sub arrays.
- The terminals shall be connected to copper bus-bar arrangement of proper sizes to be provided. The junction boxes shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Suitable markings shall be provided on the bus-bars for easy identification and weather resistant cable ferrules shall be fitted at the cable termination points for identification.
- shall have a SCADA Communication device with all necessary equipment for communicating with main SCADA Server.

The Junction Box shall also have suitable surge protection. In addition, over voltage protection shall be provided between positive and negative conductor and earth ground such as Surge Protection Device (SPD). The maintenance free earthing shall be done as per the relevant standards.

Bidder is required to propose appropriate type of cleaning system in their Technical Proposal.

2.4.1.1.2 DC cabling

The DC cables shall be selected and mounted in a way to withstand the external influences on site like temperature, UV irradiation, wind, and mechanical load.

For DC cables from PV modules to DC combiner box, it shall be PV1-F DC1800V, single core cables. For DC cable from combiner box to inverter, XLPE insulated PVC sheath flame retardant flat armor cable is selected. For MV cable, XLPE insulated PVC sheath flame retardant flat armor cable is selected.

Aluminum core cables are used for medium voltage collection lines. Voltage drop calculation is committed to guarantee the voltage drop for AC cables and DC cables meet the requirements at the plant's nominal output under any weather condition. Water proof sheath of the cables is selected in this project. Cables in PV plant will be laid along the tray with the protection of pipe.

Temperature range shall be 0°C to +90°C. All string and main cables is permanently labeled at both ends. The label shall indicate at least the corresponding inverter and string number. The final labeling is subject to the Owner's approval.

All cables and their conductors shall be supported in such a way so as to ensure that no weight is taken by the terminations.

The cables shall not be laid exposed to direct sunlight.

2.4.1.1.3 DC connectors

PV DC connectors for string interconnection shall be of the same brand and type as used by the PV module manufacturer. In no case connectors of different brands are to be used in the same connection (male -female). Under no circumstances it is allowed to cut the PV module cables and to install other than the original connectors. DC connectors shall be IP 67.

2.4.1.1.4 Inverters

The inverters shall be designed to be able to transmit the maximum output of the solar PV Module at all possible ambient temperatures and local conditions (e.g. dust atmosphere). The Contractor shall offer either central inverter or string inverter.

The inverters shall be selected for grid tied applications, central type, TN-S system (separate PE and N conductors) and operate at 50 Hz grid frequency.

The inverters shall include the following features:

- Total harmonic distortion shall be as per GTP
- Maximum efficiency $\geq 98.7\%$
- European efficiency $\geq 98.4\%$
- Maximum input voltage of 1500 VDC
- AC output voltage $\geq 400V$

- The inverters shall be capable to generate matching MVAR corresponding to maintain the power factor 0.85 lagging at delivery point, so that there is no adverse effect on the Grid System. Inverters shall be capable of operating at varying power factor in between 0.9 lag to 0.8 lead and shall be able to inject or absorb reactive power.
- Minimum frequency operation range 47 Hz-51Hz
- Nominal AC power 3150 kVA@50°C or above.
- Corrosion prevention (anti-corrosion requirement) due to marine, salty and tropical environment
- Power Conditioning Unit (PCU)/ Inverter shall consist of an electronic inverter along with associated control, protection and data logging devices.
- Inverters shall be equipped with power islanding prevention system and shall be capable of low and high voltage ride through feature.
- The inverters shall be capable of automatically synchronizing with the grid. All required functions shall be provided in the inverter for safe and reliable auto synchronization
- Each inverter shall be connected to the grounding system with a cable of adequate diameter as per manufacturer's guideline.
- Inverters should be equipped with appropriately designed EMC filters at either ends and sine wave filters at the AC end.
- Inverters shall be equipped with all required hardware for data collection and communication with SCADA system. It shall have a facility of direct external communication and control to the Employer. A proven communication protocol such as Profibus, Modbus, Ethernet, or equivalent shall be provided by the Contractor. The selected communication protocol shall be compatible with Plant Control and Monitoring System (PCMS). The inverter shall be able to be controlled by PCMS in order to maintain maximum active power, if required to ensure the grid stability.
- Inverters shall be equipped with appropriately sized forced ventilation system. There shall be redundancy in operation with standby fans.
- Inverters with outdoor duty installation shall have a minimum degree of protection of IP54.
- The inverter corrosion protection requirement is minimum C5-M. The corrosion protection requirement shall be supported by test report.
- Inverter shall have protection against:
 - Over current
 - Ground Fault Detector
 - Over temperature
 - Over voltage
 - Reverse current
 - Anti -Islanding Certificates

The inverters should be TUV-tested for the required Certificates, CE-marked and in compliance with the applicable standards also must comply with the IEC 61683; IEC 61000-6-4, IEC6100-6-2, IEC 62109-1; IEC62109-2; UL 1741 and IEEE 1547

Warranty

The warranty period of the inverter, unless otherwise specified, shall start from the date of issuance of the Operational Acceptance Certificate (OAC) by the owner and end after 24 (twenty four) months of operation until final acceptance.

Testing of Inverters

Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) to be carried out by with the presence of witnessing committee. The Inverters shall be completely tested in the manufacturers' workshop in accordance with applicable codes and standards. The tests shall at a minimum include:

- a. Check of protection against overload, short-circuit, grid-failure, internal failure, over-temperature (de-rating), surge protection, detection of insulation faults of AC Cables. Bidder shall firmly specify the manufacturer, types and length of cables to be installed;



- b. Test run in the field for maximum efficiency of all inverters;
- c. Test run and check of MPP tracking of all inverters;
- d. The Contractor shall deliver detailed protocols of the performance test run (warm power test) for every single inverter;
- e. The on-site measurements shall be accepted by the Contractor as average values for all inverters.

The Inverters shall be tested on site to ensure proper functionality during e.g.

- a. Visual inspection after delivery on-site
- b. Thermal Heat Inspection to ensure no overheating
- c. Pre-commissioning (including “loop testing”)
- d. Commissioning and test on completion
- e. Performance tests

Testing according to IEC 61683

2.4.1.1.5 LV/33kV transformer LV/33 kV

The step-up transformer located in PV Transformer station shall be outdoor oil immersed with two windings 3150kVA (minimum), according to IEC 60076-2 standard. 0.6kV for the LV side of the transformer is tentative, and the contractor can optimize it based on the capacity of the central inverter and it shall be confirmed by the employer.

The Contractor can also offer Double-split windings transformers.

If not specified otherwise, the following temperature rises shall not be exceeded:

- top oil temperature 50°C
- average winding temperature 55 °C
- winding hot spot 68 °C

As a rule, all transformers and their accessories must be designed for their intended installation. All component and accessory parts must be constructed using carefully selected materials and be of appropriate design to match the service life of the transformer. The manufacturer will be responsible for the selection of all materials used in the transformer. The transformers shall be equipped with Buchholz protection (transformer tank and tap-changer).

The LV/33kV transformer shall be designed to be able to transmit the maximum output of the corresponding unit at all possible ambient temperatures on site. The Contractor shall provide with his proposal a diagram showing the capacities of the step-up transformer versus the ambient temperature on site.

If hermetically sealed or sealed-tank design (maintenance free) transformers are offered and ordered, the tank supervision/protection shall be adapted to sealed-tank conditions.

Core

Transformer shall be double wound, core type with low loss, non-ageing, high permeability, PRIMEGRADE, CRGO with M4 grade or better, perfectly insulated and clamped to minimize noise and vibrations. Transformer shall be of bolt less core design.

The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand voltage of 2000V for one minute.

Winding shall be made with 99.9% pure electrolytic grade copper, insulated with high grade paper insulation. Manufacturer shall provide preferably foil windings for LV coils so as to reduce the stray loss and overall surface area. The HV & LV winding should be able withstand thermal and mechanical stress in the event of short circuit.

The framework and clamping arrangement of core and coil shall be securely earthed inside the tank by copper strap connection to the tank.

Transformers shall be fitted either with bushing insulators or with cable boxes/cable box with disconnecting chambers. The Cable Boxes shall be suitable for termination 3 Runs of 300 Sq.mm XLPE cable.

The neutral of the star-connected winding shall be brought out to a separate bushing terminal. The neutral bushing shall be provided on the tank side to facilitate lead of the earth conductor down to the ground level. For transformers 1000kVA and above, tank mounted pin type support insulator shall be provided for supporting the neutral earthing bar of specified section, along its run from the neutral bushing to ground-level.

When bus-duct termination is required, a flanged bushing connection shall be provided. The winding terminations shall be brought out on outdoor type of bushings.

Bushings shall be designed and tested to comply with the applicable standards. If type test certificates are not available, these tests shall also be carried out in addition to the routine tests. Bushing rated for 400A and above shall have non-ferrous flanges and hardware. Fittings made of steel or malleable iron shall be galvanized.

Whenever required, bushing shall be supplied with current transformers. Secondary leads, including tapping, shall be brought to a weatherproof terminal box near the bushing. Bushing C.T. nameplate shall be mounted on the tank adjacent to the terminal box.

Disconnecting chamber shall be provided to enable the transformer to be removed without unsealing the cables or draining oil from the main tank. The disconnecting chamber shall be air insulated and complete with seal-off bushings, removable flexible connectors/links and removable covers.

Phase to phase and phase to ground clearances within the chamber shall be such as to enable either the transformer or cable to be subjected separately to H.V. tests.

The interconnection cabling between the marshalling box and the accessory devices shall be by either PVC insulated wires in GI conduits or PVC insulated armored cable and necessary compression type, brass cable glands at the marshalling box for the above-mentioned cables as well as for terminating incoming cables from remote panels.

The marshalling box shall be tank mounted, outdoor, weather-proof, sheet-steel (2 mm thick) enclosed, with hinged door having padlocking facility and painted. All doors, covers and plates shall be fitted with neoprene gaskets. Bottom shall be at least 600 mm from floor level and provided with gland plate and cable glands as required. Top surface shall be sloped.

All contacts for alarm, trip and indication circuits shall each be electrically free, wired for auxiliary D.C. supply and brought out to separate terminals at the terminal blocks in the marshalling-box. Terminals shall be rated for 10A. Wiring shall be with stranded, copper conductors of sizes not smaller than 1.5 sq.mm for control and 2.5 mm for C.T. circuits. C.T. terminals shall be provided with shorting facility.

Transformers shall operate without injurious heating at the rated KVA at any voltage within +10 percent of the rated voltage of that particular tap.

Transformers shall be designed for 110% continuous over fluxing withstand capability. Overload shall be allowed within the conditions defined in the loading guide of the applicable standard. Under these conditions, no limitations by terminal bushings, tap/changers or other auxiliary equipment shall apply.

Transformer oil shall be as per GB 2536-2011. It shall be “PCB free and polycyclic Aromatic Hydrocarbons free mineral oil”.

For oil immersed type transformers, following fittings shall be provided:

- Bushing Terminals complete with connectors
- Neutral bushing terminal complete with connector for earth conductor
- Inspection cover (for transformers 1000 KVA and above)
- Rating and terminal marking plates
- Two earthing terminals
- Lifting lugs for lifting complete transformer with oil and lighting core and coils
- Drain cum sampling valve with plug or cover plate



- Dehydrating breather (for transformers 36 KVA and above for rated voltage 33 KV and below and all ratings above 11 KV)
- Oil level Indicator with minimum marking
- Thermometer pocket
- Oil flag hole with cap (for transformers without conservator)
- Conservator (for transformers 50 KVA and above for rated voltage 33 KV and below, and all rating above 33 KV with oil flag hole with cap and a drain plug)
- Air Release Device (for all transformers fitted with conservators)
- Jacking Lugs (Transformers weighing above 3000 Kg)
- Filter Valve (for all transformers above 1000 kVA)
- Explosion vent with diaphragm/pressure relief valve (for transformers 50 KVA and above).
- The device shall be rain-proof after operation. An equaliser pipe connecting the pressure relief device to the conservator shall be supplied
- The under base provided with channels for fixing on a platform or plinth
- One (1) top filter valve with blanking plate.
- One (1) bottom filter valve with blanking plate
- Four plain rollers in place of fixing channels.

Tests

Testing procedures and techniques are to be in accordance with normal accepted industry practice and the appropriate standards. To minimize potential damage to the transformer during testing, the resistance, polarity, phase relation, turn ratio, no-load loss, percent impedance, temperature rise (when applicable), and load loss tests should precede dielectric tests. In this sequence, the beginning tests involve voltages and currents, which are usually reduced as compared to rated values, thus tending to minimize damaging effects to the transformer. The dielectric test sequence shall be arranged so that lightning and switching impulse tests precede the power frequency tests, and the final dielectric test performed shall be the induced overvoltage test.

voltage grade	1 minute power frequency overvoltage	surge voltage
11kV	28kV	75kV Peak
22kV	50kV	125kV Peak
33kV	75kV	175kV Peak

N.B.: For string type inverter, transformer technical specifications are mentioned in GTP

2.4.1.1.6 Deleted

2.4.1.1.7 LV Auxiliary Distribution System

The LV auxiliary distribution system shall include (but not limited to):

- MV/LV auxiliary transformer (& Grounding transformer)
- One LV auxiliary distribution board

The auxiliary transformer shall be sized according to the power consumption of the auxiliaries.

The LV distribution board shall be composed of two separated compartments with segregated equipment (circuit breaks, terminals, etc.) for normal and back-up power supply external stable supply.

2.4.1.1.8 33kV switchgear

All equipment and material shall be designed manufactured and tested in accordance with the latest applicable IEC standard 62271-200/100.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case copies of English version of the standard adopted shall be submitted.

The high-tension switchgear offered shall in general comply with the latest issues including amendments of the following standards but not restricted to them.

This specification covers design, manufacture, testing and supply of 33kV Metal-armored with drawable switchboard (indoor).

Applicable Standards

The Switchgears shall be manufactured to the highest quality consistent with best practice and workmanship and in full accord with the Supplier's quality assurance plan. The SWITCHGEARS shall conform to the Chinese or IEC international standards that are applicable. These include the standards listed below.

Standard	Description
IEC:62271-100	Switchgear
IEC:62271-100	Internal arc classification and loss of service continuity classification
IEC 60694	Common clauses for MV switchgear standards
IEC-80441 -1	Current Transformers
IEC-60441-2	Voltage transformers
IEC-61243, IEC 61958	Voltage detection system
IEC 60529	Protection against accidental contact, foreign bodies and water

Design Criteria

Service conditions

The equipment shall be suitable for operation in tropical climate considering design ambient temperature of 40°C Temperature rise shall be as per IEC 694.

The switchgear shall meet the criteria for compact, metal-enclosed switchgear in accordance with IEC 62271-200, IEC 60694:

- Switchgear classification: PM class
- Loss of service continuity class: LSC2B
- Internal arc tested for 31.5 KA, 1sec, IAC-FLR

Degree of protection for panel shall be IP 41. The switchboard shall be suitable for Short Time Current of 31.5kA for 1 secs, Breaking current and Making current shall be 31.5 kA at 36 kV and 80kAp respectively. All the HV compartments shall be tested for Internal Arc of 31.5kA for 1sec. Power frequency withstand voltage shall be 70kV rms. Impulse withstand voltage shall be 170kVpeak.

The circuit breaker shall be tested for cable charging and capacitor duty for minimum "C2" category of latest IEC.

All of the switchgear shall be capable of withstanding these parameters without any damage being caused, in accordance with the standards mentioned in this specification

Construction features of the switchboard

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Switchboard shall be factory assembled, totally enclosed, metal clad, dead front cubicles. It shall be completely wired with all electrical accessories as specified in the Bidding Document.

Switchboard shall be dust, moisture and vermin-proof. All louvres shall have screens and filters. Vent openings shall be so arranged that hot gases or other material cannot be discharged through them in a manner that can injure the operating personnel. Pressurized gas shall get discharged only from the top of the respective HV compartments.

Sheet steel shall preferably be galvanized to avoid rusting. Sheet steel thickness shall be as per manufacturer's type tested design. Cubicles shall be fitted with removable gland plates of non-magnetic material with built in adjustable cable holding clamps. It is preferable to have fabricated cubicle with riveted design.

Switchboard shall have separate vertical section (panel) for each circuit breaker.

Separate compartments shall be provided for circuit breaker, low voltage instruments, bus bars and cables. Current transformers shall be mounted in the cable compartment, on a roller, for ease of handling. Line potential transformers shall be mounted at the rear side of the respective breaker panel. Bus potential transformer shall be housed in a separate trolley, placed in a separate panel. It is mandatory to have P.T. primary fuse replacement without switching OFF the breaker. Assembly of all current carrying parts shall be such that they shall be easily accessible for inspection and maintenance. Separate explosion vent shall be provided for each of the Compartments; circuit breaker, bus bar and cable.

Seal off bushing shall be provided between the breaker and bus bar compartment and also between the breaker and the cable compartment.

The panel shall be designed for accommodating 6 runs of 1Cx630 sq mm cable or 2 runs of 3Cx400 sq mm cable, without using any rear cable extension chamber. Head room clearance for cable termination shall be minimum of 750 mm. Power cable entry shall be from the rear bottom of the panel. Control cable entry shall be from the front bottom of the panel, along the either side of circuit breaker. Split gland plate with adjustable cable holding clamp shall be provided.

Switchgear shall have following interlocks:

- Movement of CB from test to service position shall be possible only when all the following conditions are met with:
 - ❖ The breaker is in OFF position.
 - ❖ The auxiliary plug and socket is engaged and locked.
 - ❖ CB compartment door is closed.
 - ❖ Rear covers are closed.
 - ❖ Earth switch is OFF.
- Movement of CB from Service to Test position is possible only when the CB is OFF.
- Front door of breaker compartment cannot be opened unless breaker is tripped and brought to test position.
- Auxiliary plug and socket cannot be opened unless the CB is brought to test position.
- Earth switch in the outgoing side (rear side) can be made ON only when circuit breaker is switched OFF and brought to test position.
- Rear cable cover cannot be opened unless breaker is OFF and brought to test position & the earth switch is ON.

Metallic shutters shall be provided to prevent accidental contact with main stationary contact or other live parts when the circuit breaker is drawn out. When the circuit breaker is inserted back in the cubicle, it shall allow the circuit breaker to continue its travel until it fully engages the main stationary contacts. Suitable guides, slides and stops for proper positioning of the truck or trolley with the circuit breaker shall be provided to ensure easy removal, replacement and positioning of the circuit breaker. All circuit breakers of same rating shall be interchangeable with one another. Provision shall be made to prevent entry of circuit breaker of different rating even though the cubicle width remaining same. It is preferable to have cubicle width not exceeding 1000mm.

Each circuit breaker cubicle shall be provided with cable earthing switch at the rear side with due interlocks as stated earlier. Earth switch shall be tested for full fault make current, as well as short time rating. Provision shall be made for the operation of earth switch both from front as well as rear.

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Instruments and relays shall be mounted on the hinged type of front door of the metering compartment.

Sheet steel used for fabrication shall be ID rolled carbon annealed only and fab reaction shall be done through CNC turret punch press and CNC bending machine. Painting is through epoxy based electrostatic powder spray or sheet steel shall be of Aluzinc material without painting.

Breaker compartment door shall get locked at various points with one lever operation. It shall not always necessitate bolting at various points for safety and reliability. Doors and covers shall have several hinge points for proper locking to avoid opening of the same in the event of internal arc.

2.4.1.1.9 33kV Evacuation Switchyard

Not Applicable

2.4.1.1.10 Auxiliary service

Not Applicable

2.4.1.1.11 Power and Control Cable

MV Power Cables

For the connection between LV/33kV transformers and connection between two LV/33kV transformers and the 33kV switchgear in distribution unit Building in PV plant, the 33kV XLPE cable shall be used with all accessories including the installations of the cable terminations into the related switchgear housings and the required cable supporting systems, and primary injection tests for the cable and 33kV switchgear protection before energizing.

The 33kV cable shall be XPLE insulated, longitudinally watertight cable.

The Contractor shall design the MV rings to interconnect all Compact substations according to the IEC60502-2 by applying corresponding derating factor depending on the environmental site conditions and design characteristics.

The 33kV devices and 33kV line shall be designed to withstand the energy evacuation through one feeder at PV Plant's maximum rating.

The 33 kV cables shall be tested according to IEC 60840:2011 standard.

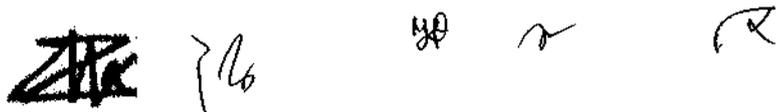
All cables outside the transformer must be covered to protect them against mechanical damage. Where these covers are to be walked on, they must be stable enough. Cables going downwards over the edges of the transformer cover must be covered beyond the edge.

LV AC and Control Cables

LV AC power and control cables for the interconnection of the inverter and the LV/33 kV transformer, shall be provided with all accessories including the installations of the cable terminations into the related transformer and inverter and the required cable supporting systems including LV AC cable size calculation according to the IEC 60364-5-52.

Low voltage, XLPE insulated, PVC inner sheath, SWA, PVC outer sheathed power and control cables for above ground installation:

- rated voltage: 0.6/1kV; 1.8/3kV
- Low voltage power cables and control cables use copper cores. The grade and quality of the copper used for the conductor shall have purity of the order of min. 99.5%. Circular or shaped section. Minimum size for power cables shall be 4 mm² and for control cables 1.5 mm².
- insulation - Cross linked polyethylene (XLPE)
- The cable shall be waterproof.
- Conductor Lay - Cores laid up with extruded non hygroscopic polypropylene filler for up to 5cores. For 6 cores or more wrapping of polyester tape.
- Inner Sheath/Bedding -Extruded polyvinyl chloride.
- Armoring - Multi core cables shall have galvanized steel wire. Single core cables shall have aluminum wire armoring.



➤ Outer Sheath - The outer sheath of cable shall be an extruded layer of polyvinyl chloride having oxygen index not less than 30, colored black. The outer sheath shall be flame retardant to IEC60332-3-22 and type tested for reduced propagation.

➤ The maximum voltage drop in the cables of any AC circuit from the inverter output to the MV switchgear shall be < 1.50% at STC.

2.4.1.1.12 Earthing and Lightning Protection

Earthing System

The earthing system shall be designed according to the following standards (but not limited to):

- IEC 60364(4-41) Low-voltage electrical installations: Protection for safety - Protection against electric shock.
- IEC 60364(5-54) Low-voltage electrical installations: Selection and erection of electrical equipment - Earthing arrangements and protective conductors.
- IEC 61936-1 Power installations exceeding 1kV A.C.- Common rules.
- EN 50522 Earthing of power installations exceeding 1kV A.C.
- IEC 60364-7-717 Low-voltage electrical installations: Requirements for special installations or locations -Mobile or transportable units.

It shall be designed without taking the connections to adjacent earthing grids into account, i.e., the earthing and lightning protection system shall be designed as self-contained system.

For earthing , protective earthing , functional earthing , potential equalization and lightning protection-potential equalization, one common system shall be established.

Prior to drawing up design the Contractor shall carry out a series of soil resistivity measurements at each site. These measures shall be made using the Wenner four-electrode method.

The Contractor must choose the size of the stranded copper conductor and the size of mesh according to the maximum occurring ground fault currents.

The PV field shall be installed as an equipotential surface, all metallic equipment and structure shall be grounded, all PV modules shall be grounded according to local rules and regulations. Step and touch voltage calculation shall be undertaken by the Contractor and provided to Employer for review.

After the construction the step and touch voltage measurement shall be done by the Contractor and provided to Employer for review.

The resistance of the grounding system shall not exceed 0.5 ohm.

After installation of the earthing and lightning protection system, but before connection to adjacent earthing grids, measurement of earth resistance and other safety features of the earthing design shall be carried out.

Lightning and Overvoltage Concept

A lightning and overvoltage concept shall be designed according to the IEC 62305 (all parts). PV Plant shall be equipped with lightning protection system LPS I according to the IEC 62305.if the result of risk assessment (according to the IEC 62305-2) proposes is different, LPS class than this is also acceptable.

The components and systems belonging to the lightning protection systems are listed below:

- external lightning protection
- internal lightning protection.

External lightning protection includes:

- air terminals on the roofs of buildings.
- down conductors as connection to the earthing system
- external earthing system.

Internal lightning protection includes:

- lightning protection equipotential bonding
- earthing of cable trays, cabinets etc.

- shielding of cables
- surge protection devices.

Connecting points of the external and internal lightning protection and metal parts of the building structure for equipotential bonding strips.

The structure to be protected is the complete PV Plant including the service buildings, transformer stations, Substation and solar array.

The criteria for design and installation of lightning protection measures shall be aimed to fulfill the following criteria:

- protection measures to reduce physical damage to structures and life hazard in a structure according to IEC 62305-3.
- protection measures to reduce failures of electrical and electronic systems in a structure according to IEC 62305-4.

The lightning protection shall also comply with all the applicable international standards (IEC62305-1; IEC 62305-2).

In order to protect the junction boxes and the inverters of possible damages due to surge voltage in case of lightning stroke directly in or near the PV field, surge protective devices (SPD type I and SPD type II) shall be included. In addition, for communication and data lines, SPD type II devices shall be installed. Due to the expected distance between the combiner boxes and the inverters, both equipment shall be protected. SPDs type I and SPDs type II according to GB/T 18802.11-2020 shall be installed in the DC PV module circuit. On the inverter side the SPDs are to be installed on the DC, AC, and control sides.

2.4.1.2 132kV substation

2.4.1.2.1 General

The overall electrical concept and interconnection of the PV Plant substation is outlined in the tentative Single Line Diagram (SLD).

The substation consists of 132kV switchyard, 132/33KV transformer, 33kV switchgear, 33/0.4 kV auxiliary transformer, LV switchgear,SVG and auxiliary system.

The Transformer Stations of the PV plant shall be connected to the 33 kV switchgear located in substation via 33 kV cables.

The 33 kV switchgear shall be a single busbar system, two sections consisting of following feeders:

- incoming feeder from the PV plant
- outgoing feeder to 33/132kV transformer
- auxiliary transformer feeder
- SVG feeder.
- earthing device feeder.

The 33 kV switchgear room shall have additional spare sufficient for future extension.

Low power distribution system for PV Plant Substation installed in Control building consists of:

- 33/0.4 kV indoor dry type auxiliary transformers. The Contractor shall submit detail design of auxiliary system. Auxiliary Transformers shall be rated based on the rating of the loads it has to supply.
- Auxiliary service shall be calculated and designed by the Contractor consists of:
- UPS Battery Emergency Power Supply (DC and Safe AC) for entire PV Plant
- Internal/external lighting and emergency lighting systems
- Air conditioning in all buildings
- Power supply of CCTV



- Power supply of fire detection and alarm system
- The 220V DC main distributions are fed by 1 x 100% rectifiers and 1 x 100% batteries. The main distribution safe AC supply is fed by 2 x 100% inverters with electronic changeover unit.

The PV Power Plant substation shall be connected to Matarbari 132kV Grid-Substation via 1(one) 132KV double-circuit overhead transmission line and 2(two) 132kV receiving bays in Matarbari 132kV Grid Substation. The interface point shall be connection of the 132kV Busduct in 132kV bays in Matarbari 132kV Grid Substation.

Metering devices of electrical signals such as frequency, voltage, active power, reactive power, and energy shall be provided:

- Tariff metering point shall be at the grid connection point (new bays in Matarbari 132kV Grid substation) and Operational metering point shall be at 132kV side of the step-up transformer inside the PV Plant premises and two (2) meters (main and backup) shall be installed in the indoor metering panel in both metering points. In addition, DC Energy Meters shall be provided on the input side of each central inverter. The Tariff Meter and corresponding CT/PT must comply with BPDB standards, and all conditions warranted by BPDB during commissioning and COD must be complied with.

2.4.1.2.2 Voltage Levels

The following voltage level requirements shall be observed:

Item	Voltage	Star Point
Grid Connection voltage	132kV,50Hz,3 Phase	According to the BPDB/PGCB Standards
MV Voltage	33kV,50Hz,3 Phase	According to the BPDB/PGCB Standards
DC/AC inverter voltage	Voltage according to manufacturer,50Hz,3 Phase	According to the BPDB/PGCB Standards
DC system	220V DC	Underground Neg. Pole solidly grounded
Power Distribution System low voltage	400/230V,50Hz,3-phase,+N+PE	Solidly grounded
UPS	230V AC	solidly grounded

2.4.1.2.3 Protection Class of Equipment

- The international protection class of all MV and LV switchgear as well as of all control and protection panels shall be minimum IP41.DC rectifiers and inverters (UPS) shall be minimum IP31.
- Outdoor inverters shall be IP65.
- MV switchgear housings and similar enclosures shall be equipped with air conditioning
- Outdoor installed equipment shall be minimum IP54 and shall be provided with sunshades.
- Electric motors shall be of min. protection class IP54.
- Equipment installed in non-ventilated rooms and/or areas shall be minimum IP54.

2.4.1.2.4 MV Switchgear

The 33 kV switchgear room shall be air conditioned and shall be satisfied the related standard requirement..

The MV switchgear shall be designed for a nominal voltage of 33kV (according to IEC 60038), to be internal arc certified IAC=AFRL according to IEC 62271-200 and to withstand a short-circuit current of minimum 10% higher than required by calculations for a duration of one (1) second.

For 33 kV switchgear a minimum loss of service continuity of category LSC2B-PM according to IEC62271-200 is required.

The 33 kV switchgear shall be of air-insulated switchgear for indoor installation with draw-out type switching devices. The cubicles shall be provided with a single busbar system and circuit breakers.

The switchgear needs to be equipped with SF6 circuit breakers for the SVG circuit, and all other incoming and outgoing feeders should be equipped with vacuum circuit breakers and equipped with motor driven energy storage mechanisms. Isolation switch All circuit breakers should be provided with isolation switches on both sides..

The 33 kV cubicles must be tested for resistance to accidental arcing and must fulfil IEC 62271-200:2011 Part 6 for the rated short-circuit currents and room heights indicated.

The MV cubicles shall be equipped with ground connections designed for the maximum earth-fault current the base frame must be included in the switchgear earthing system.

Arc-proof, asbestos-free partitioning of the individual compartments against each other, as well as to the other cubicles and to the false floor or cable floor.

The MV switchgear shall be designed at least to enclosure type IP 41. Anti-condensation heaters shall be provided.

Any formation of condensation water must be prevented by appropriate heating in the switchgear, controlled by one surface humidity and one temperature control device per switchboard. One heating power supply of UPS for each cubicle shall be provided for the switchgear installation.

The busbar compartments must be bulk headed from panel to panel by arc barriers. Within the cubicles, the compartments for circuit breakers, busbars , instrument transformers and cable connections as well as the relay compartment must be bulk headed from one another.

Sufficient pressure relief must be provided in the case of fault arcs. For each bulk headed compartment a separate pressure relief must be provided. Care must be taken that in the event of arcing no hot gases escape to the front of the cubicle (operational side).

The switchgear and main equipment items are at least the following:

- steel-clad, bulk headed design, the various functional compartments (circuit breaker, busbar, cable connection and relay compartments) are separated from one another by multiple bulk heading
- single copper busbar system
- The switchgear needs to be equipped with SF6 circuit breakers for the SVG circuit, and all other incoming and outgoing feeders should be equipped with vacuum circuit breakers and equipped with motor driven energy storage mechanisms. Provision is to be taken that when the switch is withdrawn, the insertion contacts are automatically covered with shutters so as to prevent any danger of accidental contact
- cable connection compartment with the necessary current and voltage transformers, the earthing switch, including the necessary fixing for high voltage cables
- fuses and voltage transformers for busbar measurement and earth fault protection
- protection relays, coupling relays, mini circuit breakers, complete terminal boards, meters etc. Including the illumination with fluorescent tubes
- mimic diagram on the front of each cubicle consisting of graphical symbol and position indication
- heating units within the switchgear panels
- earthing truck or integrated busbar earthing for each switchgear installation
- fire-proof closure to the floor of the switchgear panels to seal the outgoing power cables.

A colored mimic diagram is to be provided on the front of each switchgear cubicle with the necessary graphical symbols and indicators lamps.

The switchgear shall be controlled from remote and the local control compartment.

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The control of the circuit breakers is to be carried out with 220 VDC. The circuit breakers must be able to operate satisfactorily in the voltage range between $100 \pm 20\% U_n$.

Each circuit breaker must be capable of being operated locally by means of "close" and "open" "push buttons/rotary switches that are covered in normal operation. If the control voltage fails, "the emergency open" operation of the switches must be possible. In the test position of the truck, the circuit breakers must also be capable of being operated locally.

In the event of a protective trip of the circuit breaker, means must be provided to prevent reclosing. Which can only be overridden again from the switchgear cubicle.

For each switchgear installation, the control voltage should provide at least two power supplies. The contractor shall provide decoupling diodes for control voltage; Voltage should be monitored.

Current and Voltage Transformers

CT and VT ratings shall be verified and determined by the Contractor. Detailed CT and VT sizing calculations shall be provided for Employer's review and approval during Detailed Engineering Design.

The CT and VT ratios shall suit the characteristics of the protection relays and metering equipment. Contractor shall provide suitable number, type, burden, class of CTs and VTs as necessary. The thermal withstand capability of the Instrument transformers is to be based on a disconnection time of min. 0.5 sec in the outgoing circuits to the consumers and of min. 1.0 sec in the in feeds. The instrument transformers secondary circuits must be wired individually to the switchgear cubicle terminal strip. In case of current transformers, the necessary terminals are to be equipped with short-circuit links. Cast-resin insulated, corona-free transformers are to be employed.

Current Transformers

Accuracy for metering class 0.2s

Accuracy for measurement class 0.5

Accuracy for protection class 5P

The current transformers are to be designed capable to withstand the dynamic and thermal short circuit stresses. Intermediate transformers are to be avoided. For protection and measurement separate cores are to be provided. Contractor shall provide 2-ratio CTs.

Voltage Transformers

Accuracy for measurement class 0.5

Accuracy for protection class 3P

The secondary sides of voltage transformers are in general to be safeguarded by mini circuit breakers. If the same transformer voltage is used for several purposes (e.g. measurement, protection, metering) then individual separate voltage transformer mini circuit breakers with auxiliary contact are to be provided.

2.4.1.2.5 Protection relays

Refer to the Section 6, Clause 2.4.1.2.10

2.4.1.2.6 LV Switchgear

The LV switchgear shall be of the fixed mounted design form 3b for outgoing feeders and form 4a for incomers (according to IEC 61439-2 / GB/T 7251.12-2013). The LV switchgears shall be designed as indoor switchgear installations of metal-clad, bulk-headed type.

Each switchgear installation shall be equipped with a single copper busbar system. The Auxiliary load switchgears shall be designed for a nominal voltage of 400/230V (according to IEC 60038).

The incoming feeders to the main switchgears and outgoing feeders to sub-distributions are to be equipped with motor-driven circuit breakers larger than 630A.

All remaining outgoing feeders to the rectifiers and inverters etc. shall be equipped with load breaks switches and fuses.

The LV switchgears shall be designed at least to protection class IP 41. Anti-condensation heaters shall be provided.

The switchgear installations shall comprise at least:

- steel-clad switchgear cubicles, bulk-headed design, the various components are separated from one another.
- Busbar earthing studs including earthing fittings
- cable paralleling arrangements with auxiliary busbar systems, connecting bars for all infeed and outgoing feeds which require more than two parallel cables
- fireproof enclosures to the base of the switchgear panels for sealing the outgoing power cables
- auxiliary transformers for control voltage (where necessary)
- heating systems within the switchgear panels.

DC and safe AC distributions may be of fixed installed type Form 2b according to IEC 61439-1. Appropriate certificates must be supplied.

The LV auxiliary load network shall be of TN-S (separate PE and N conductors).

2.4.1.2.7 Auxiliary Transformer

Auxiliary Transformer shall be rated based on the rating of the loads it has to supply. The Contractor shall submit detail design of auxiliary system. For the dry-type transformers the temperature rise shall not be exceed 90°C.

All component and accessory parts must be constructed using carefully selected materials and be of appropriate design to match the service life of the transformer. The manufacturer will be responsible for the selection of all materials used in the transformer.

The auxiliary transformers shall also be designed for the ambient conditions on site. Bidder shall provide with its proposal a diagram showing the capacities of the auxiliary transformer versus the ambient temperature on site.

2.4.1.2.8 Power and Control Cable

For further information refer to the Section 6, Clause 2.4.1.1.11

2.4.1.2.9 Earthing and Lightning Protection

Refer to the Section 6, Clause 2.4.1.1.12

2.4.1.2.10 Protection

Note: the present clause only represents a preliminary guideline for the Contractor on design of protection equipment. During the detail design phase, the Contractor is requested to liaise with Employer in order to coordinate the general philosophy of protection in 0.4kV and 33kV and 132kV switchyard. The Contractor shall perform the protection coordination study and relay settings and submit to the Employer for their review and approval. The study relay settings shall be performed for all involved substations.

The protection relay for the 132kV switchgear equipment shall be installed in the control building.

All relays shall be digital type with event recording.

33kV switchgear shall at least equipped with the following protections:

33kV PV plant feeder protection shall be equipped with the following functions (but not be limited to):

- ANSI 67/67N Directional over current protection (earth/phase)
- ANSI 51G Sensitive earth over current protection (core balance CT)

33kV auxiliary transformer feeder protection shall be equipped with the following functions (but not be limited to):

- ANSI 50N/51N Earth over-current protection
- ANSI 50/51 Phase over-current protection
- ANSI 51G Sensitive earth over current protection (core balance CT)



33kV spare feeder protection shall be equipped with the following functions (but not be limited to):

- ANSI 50N/51N Earth over-current protection
- ANSI 51G Sensitive earth over current protection (core balance CT)

132kV Transformer Protection

Recommended protection system for Step-up Transformer includes the following:

- Overall differential
- Transformer differential
- Over current and earth fault
- Winding temperature
- Oil temperature
- Sudden pressure/gas protection
- Tap changer surge

In the step-up transformer duplicated protection; one shall be designated as “overall differential protection” and the other as “step-up transformer differential protection”. The unit transformer shall be equipped with differential protection and also be included in the zone of the “overall differential protection”.

2.4.1.2.11 Auxiliary Service in Control Building

2.4.1.2.11.1 General

For main distributions for the auxiliary power supply refer to LV equipment

The Contractor shall supply, all requested auxiliaries (but not limited to), such as:

- UPS Battery Emergency Power Supply (DC and Safe AC)
- internal/external lighting and emergency lighting systems in Control building
- air conditioning in Control building
- power supply of CCTV
- fire alarm system

The Bidder shall submit the proposed auxiliary supply system with his Proposal.

Power supply systems may be categorized into essential and non-essential groups. Essential supplies should be continuously available without any interruption, whereas non-essential ones may be allowed to be subject to interruptions.

Low-voltage AC and DC systems shall be designed in accordance with the IEC 60364.

2.4.1.2.11.2 DC and UPS

The uninterruptable power supply system (UPS) shall serve the consumers which have to remain in operation in the event of the network failure i.e. emergency lighting, measuring, control room, CCTV, fire alarm system etc.

Some equipment (e.g. MV switchgear circuit breaker heaters) may require the provision of changeover power supplies.

The 100% load of 220/380V AC (Safe AC), 220V DC and 48V DC are to be defined by the Contractor providing classification of consumers and their required backup time values.

The UPS system shall consist of:

- rectifier/battery/inverter set
- static switch by-pass and maintenance by-pass set
- three phase AC distribution board.

The DC system shall consist of:

- AC/DC rectifier
- batteries

➤ DC distribution board.

The rectifiers and inverters shall be arranged in sheet steel cubicles, which shall be matched to the distribution cubicles in respect of height and other dimensions.

The rectifiers and inverters shall be designed for operation with natural cooling. If forced air-cooling is required, then 2 x 100% air fans with monitoring and local and remote alarm signals must be provided.

The DC distribution is to be fed by 2x100% batteries and rectifier.

The digital control system (DCS) shall be supplied from a 48V DC system. Redundant 48V DC distribution system shall be provided.

The cubicles of 48V DC consumers shall be supplied by redundant feeders. Redundant Safe AC system shall be provided.

230V Safe AC system comprises one inverter with static bypass switch unit and a safe busbar. The inverter shall be supplied from sections of the 220V DC main distribution. The static bypass switch shall be supplied from the 0.4kV essential switchgear.

The 220V Safe AC system supplies the equipment requiring uninterrupted supply (UPS) e.g. measuring, control system etc.

The outgoing circuits in the safe DC and AC main distribution shall be equipped with monitored fuse- and load-break switches, fuses and contractors, mini-circuit breakers, etc.

The individual cubicles shall be bulk headed against one another by sheet metal walls or equivalent material.

The DC and UPS shall be located inside an air conditioned room, the rectifier / charger and distribution board shall be rated for continuous operation at 40°C. Sizing of battery shall be based on a minimum of -3°C and maximum of 55°C ambient. The temperature factor and ageing factor of the battery shall be based on the above temperatures.

2.4.1.2.11.3 Battery

For the DC system, the Contractor shall supply VRLA type batteries.

The batteries shall be sized of at least 200Ah. Or, the sizing of batteries shall be based on worst case scenarios that might cause a total loss of AC services (i.e. total blackout, fault on a major bus in the installation, etc.). As a minimum, the DC batteries shall have enough capacity to trip breakers and switches at the beginning of the discharge period, to supply power to the continuous DC load and to close the elements of the installation that will restore AC services.

If applied, battery banks with exposed live parts shall be kept in a room or cubicle accessible only to authorized personnel.

Battery rooms or cubicles shall be dry and adequately ventilated to limit hydrogen accumulation. Allowable hydrogen levels and recommended number of air changes shall conform to national regulations.

Batteries shall be installed on insulated sub-frames with the necessary consoles and fixed material. At least 1.0 m access space shall be provided at the front and sides of the battery rack.

2.4.1.2.11.4 Internal / External Lighting and Emergency Lighting System

The installation method differs between internal lighting (offices, rooms for similar purposes, technical rooms) and exterior lighting.

All lighting fittings and all equipment comprising the lighting sub-distribution units shall meet the operational requirements in full at an ambient temperature of 40°C and relative humidity of up to 100%.

The lights must be connected in a 3-phase circuit, so that in an event of failure of the phase only each third lamp will go out. The cable cross section shall be calculated according to the IEC 60364-5-52.

Location of the lighting and small power equipment shall be reviewed before installation so that satisfactory co-ordination with walkways, streets, fences, gates, crossings, entries, PV panel support structures, cable ways and other installations can be assured.

The lighting systems are to be classified as follows:

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- normal lighting fed from normal supply: shall provide desired and required illumination levels in the various indoor and outdoor areas and roads
- emergency lighting fed from safe AC supply (UPS): In case of failure of normal lighting, emergency lighting shall provide sufficient illumination to allow safe movement of personnel.

In coordination with the design of the alarm and CCTV systems outdoor lighting as a minimum shall be provided for perimeter of the plant and at the entrances of all buildings on site including the transformer stations.

Indoor lighting can be operated manually and/or using automatic motion detecting devices where suitable.

In control room, switchgear rooms flush-mounted fluorescent tube fittings are to be provided. The lighting fittings are to be designed with required louvers for mounting in the suspended mineral fiber acoustic tiles.

In battery room explosion-proof lighting fitting (EExd II CT2) are to be provided. Explosion proof measures should be considered for lighting switches in battery rooms.

Outdoor lighting at the entrances of buildings and where suitable shall be operated automatically (motion detection) and also shall permit remote control from the main control room and shall be included in the concept for intrusion alarm. The perimeter lighting shall be operated centrally and also included in the security concept for the plant

The lighting shall be designed so that the lighting illumination density listed in GB 50582-2010 will be achieved. In that respect an aging factor of 20 % is to be taken into account so that new lighting densities must be achieved as a minimum in the acceptance measurement.

2.4.1.2.11.5 Fire Fighting, Protection and Detection System

The firefighting, detection and protection system shall be designed, constructed and tested in accordance with Good Engineering and Construction Practices, Contract and local regulations.

The firefighting, protection and detection system shall comply with the National Fire Protection Association (NFPA), American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME), and local regulations.

These requirements shall be met by optimizing the building and equipment layout (as passive measures) and by providing adequate warning and fire detection and protection measures (as active measures).

The scope of work shall include design, manufacture, delivery, erection, commissioning and testing of a complete fire protection, detection and alarm system. The system shall consist of fire water tank (can be combined with service water tank), diesel / electric / jokey pumps as per NFPA requirement, hose reel system around the transformer and main control room area, hydrant systems and fire extinguishers as appropriate for buildings.

For 33/132kV transformer, water spray deluge system shall be installed. Appropriate number and type of portable fire extinguishers shall be provided at each floor in each building and around the facilities in accordance with applicable standards. Locations of these portable multipurpose dry chemical and carbon dioxide extinguishers shall be proposed by the Contractor for review by the Employer.

The portable fire extinguishers shall be complete with wall mounted fixtures and clamp including supported bottom plate.

Portable fire extinguishers shall also be provided at the PV panel area and places with inverters and Combined substation.

All HVAC systems must be shut down in case of fire to prevent spread of fire.

The fire detection and alarm shall be DC operated by UPS. All fire equipment & system installed outdoor must be IP65.

2.4.1.2.12 Surge Arresters

Surge arresters shall be of gapless zinc oxide type and shall be mounted on pole line. Their design shall comply with the IEC 60099-5 and all other relevant equivalent IEC standards.

The 132kV surge arresters shall be designed for a nominal discharge current of 10 kA and shall be equipped with a pressure relief device. For each surge arrester a surge counter for monitoring the number of operations shall be provided.

The impulse spark over voltage shall be higher than the power frequency spark over voltage to discharge over voltage due to earlier switching but must be lower than the impulse test voltage of the switchgear. The arrester

shall be capable of diverting the impulse voltage caused by lightning strikes and over voltages due to switching.

2.4.1.2.13 delete

2.4.1.2.14 Protection Class of Equipment

Refer to the Section 6, Clause 2.4.1.2.3

2.4.1.2.15 MV Switchgear

Sufficient space shall be provided within the cable compartment of each feeder cubicle to install surge arresters.

For further information refer to the Section 6, Clause 2.4.1.2.4

2.4.1.2.16 LV Switchgear

Refer to the Section 6, Clause 2.4.1.2.6

2.4.1.2.17 Auxiliary Transformer

Refer to the Section 6, Clause 2.4.1.2.7

2.4.1.2.18 Power and Control Cable

Refer to the Section 6, Clause 2.4.1.2.8

2.4.1.2.19 Earthing and Lightning Protection System

In order to protect the 132kV switchgear feeders of possible damages due to surge voltage in case of direct lightning stroke, surge protective devices shall be included. In addition, for communication and data lines, SPD type II devices shall be installed.

2.4.1.2.20 Protection

Note: the present clause only represents a preliminary guideline for the Contractor on design of protection equipment. During the detail design phase, the Contractor is requested to liaise with Employer in order to coordinate the general philosophy of protection in 132kV switchyard. The Contractor shall perform the protection coordination study and relay settings and submit to the Employer for their review and approval. The study/relay settings shall be performed for all involved substations of Section. The protection relay for the 33kV switchgear equipment shall be installed in the PV plant switch yard building. All relays shall be digital type with event recording.

33kV switchgear shall be at least equipped with the following protections:

33kV outgoing feeder protection shall be equipped with the following functions (but not be limited to) :

ANSI 50N/51N

- ANSI 50/51
- ANSI 51G

33kV incoming/outgoing feeder protection (for the connection to 0.4/33 kV power transformer) shall be equipped with the following functions (but not be limited to):

- ANSI 51/51N
- ANSI 49
- ANSI 86
- ANSI 87T
- ANSI 87N

33kV incoming/outgoing feeder protection (for the connection to 0.4/33 kV power transformer) shall be equipped with the following functions (but not be limited to):

- ANSI 51/51N



- ANSI 86
- ANSI 87T

33kV auxiliary transformer feeder protection shall be equipped with the following functions (but not be limited to):

- ANSI 50N/51N
- ANSI 50/51

33kV spare feeder protection shall be equipped with the following functions (but not be limited to):

- ANSI 50N/51N
- ANSI 50/51
- ANSI 51G

All relays shall have the necessary number of auxiliary contacts able to handle the AC and DC control, communication, alarm, monitoring, supervisory and tripping functions related to the protection as well as having the capability to make and break currents that can flow in the circuits.

The required programming device software and training shall be included in the scope of supply.

The power circuits for the protection relays are to be supplied from the 220 V DC system described in Section 6, Clause 2.4.1.2.11.2. All protection relays have to be selective.

The Contractor may offer additional protection device if he sees them necessary. The same degree of accuracy of the protection must be guaranteed for ambient temperature.

2.4.1.2.21 Auxiliary Service in 132kV Switchyard

For main distributions for the auxiliary power supply refer to LV equipment.

The Contractor shall supply, all requested auxiliaries (but not limited to), such as:

- UPS Battery Emergency Power Supply (DC and Safe AC)
- internal/external lighting and emergency lighting systems in control building
- air conditioning in new 132kV switchyard building
- power supply of CCTV
- fire alarm system

The Bidder shall submit the proposed auxiliary supply system with his Proposal.

Power supply systems may be categorized into essential and non-essential groups. Essential supplies should be continuously available without any interruption, whereas non-essential ones may be allowed to be subject to interruptions.

Low-voltage AC and DC systems shall be designed in accordance with the IEC 60364.

2.4.1.2.22 132/33kV Transformer

Efficiency

The transformers shall be of highest efficiency that the Contractor can attain.

Temperature Rise

The temperature rise of the windings shall not exceed 55C when measured by the resistance method, after circulating the rated current at rated frequency in the windings under test.

The temperature rise of top insulation oil shall not exceed 55°C when measured by a thermometer in an oil filled thermometer pocket on the cover or in the outlet pipe to the cooler, and the method of the test of temperature rise will be decided in accordance with IEC 60076-2.

Dielectric Test Voltage

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The transformers shall withstand the following test voltages in accordance with IEC 60076-3.

Codes and Standards

The design, manufacturing and testing of equipment shall comply, but not limited to the latest applicable recommendations of the standards and codes specified. The following Codes and Standards are referenced in this Section of the Specification:

International IEC Electrical Standards:

- IEC 76, Parts 1 to 5 Power Transformers.
- IEC 137 Insulated bushings for alternating voltages above 1000V
- IEC 185 Current Transformers
- IEC 186 Voltage Transformers
- IEC 214 On-load tap-changers
- IEC 233 Tests on hollow insulators for use in electrical equipment.
- IEC 296 Specification for unused mineral insulating oils for transformers and switchgear
- IEC 354 Loading guide for oil-immersed power transformers
- IEC 422 Supervision and maintenance guide for mineral insulating oils in electrical equipment
- IEC551 Determination of transformer and reactor sound levels
- IEC 529 Degrees of protection provided by enclosures (IP Code)

Operating and Design Requirement

The transformers shall be suitable for operation as specified at sub-tropical site. In general all hardware and accessories shall be corrosion proof. Transformer of the same type and rating shall be interchangeable both electrically and mechanically with one another. Like parts, when inter changed, shall perform their function equally well in every respect. Suitable interfaces shall be available for the purposes of control, monitoring, indicating and alarms of the transformer conditions and associated equipment from DCS.

Electrical clearances shall not be less than those in the appropriate sections of BS 7354, or as stated in the scope of work.

Cooling - The types of cooling shall be as stated in the Schedule of Requirements and the letters relating to the method of cooling used in this Specification and Schedules shall be in accordance with IEC 60076.

Transformers shall be fitted with two banks of radiators each capable of dissipating 50% of the losses at continuous maximum rating.

Failure of any one fan in each group of fans shall not reduce the continuous maximum rating of the transformer.

In designing the transformers, the Contractor shall refer to the general arrangement of the transformer and shall consider the location of the lightning arrester.

Rated Power Output MVA

Each transformer shall have a rated power output (MVA) in accordance with this Specification and shall be capable of the following without exceeding the specified temperature rise under site conditions:

- Delivering its rated power from any winding continuously, irrespective of the direction of power flow, at any tapping, with the winding at rated voltage and frequency as specify in the Requirement.
- Cooling shall be ONAN/ONAF type for 132/33 kV transformer.
- Operating continuously at no load at any tapping, when neither the output winding voltage nor volts per hertz exceed 110% rated.

- For multi-winding transformers (if supplied) each winding shall be capable of being loaded to their specified ratings irrespective of the loading on other windings, but the arithmetic sum of the winding loads shall not exceed the source winding capability.

Temperature Rise

The temperature rise of the windings shall not exceed 55C when measured by the resistance method, after circulating the rated current at rated frequency in the windings under test.

The temperature rise of top insulation oil shall not exceed 55°C when measured by a thermometer in an oil filled thermometer pocket on the cover or in the outlet pipe to the cooler, and the method of the test of temperature rise will be decided in accordance with IEC 60076-2.

Vibration and Noise Level

The transformer Vibration and noise levels shall be measured as a type test and in accordance with IEC 551. Vibration and noise levels of transformers shall be in accordance with the best commercial practice.

Overloads

Each transformer and all component parts shall be capable of overload operation in accordance with IEC 60076-7: 2005.

Tolerances

The tolerances on the guaranteed values shall be in accordance with IEC 60076-1.

Ability to Withstand Short Circuit

- General - all transformers shall be capable of withstanding, on any tap and without any permanent damage or deterioration, the mechanical and thermal stresses of external short circuits under the conditions stated in IEC 60076 Part 5.
- Calculations and Tests - Evidence shall be submitted with the Contract as to the extent to which the manufacturer has proved or is able to prove either by calculation or test the ability of the specified Transformers to withstand short circuit.

The Contractor shall provide with his Contract a brief description of those transformers or parts thereof, which have been subjected to a short circuit test or for which short circuit calculations are available. This information shall relate to designs comparable with the transformers Contracted; in the event this is not so, the Engineer reserves the right to demand calculations that prove the design of the transformers Contracted will satisfactorily comply with this Clause.

Harmonics

The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth, so as to eliminate waveform distortion and any possibility of high frequency disturbances, inductive effect or of circulating currents between the neutral points of different transformers reaching such a magnitude as to cause interference with telephone or other communications circuits.

Tank

The power transformer shall be of such structure to permit installation at the site to be simple. Assembling work at the site such as staking of core and insertion of coil shall not be allowed. Looseness of core, yoke, coil and other parts shall not happen during transportation and long-term use.

Each transformer shall be enclosed in a suitably stiffened welded steel tank such that the transformer can be lifted and transported without permanent deformation, oil or gas leakage and capable of withstanding 125% of the maximum positive and negative operating pressures as a minimum. The tank construction shall make use of weldable structural steel of an approved grade to BS 4360. Aluminium tanks shall not be considered. A minimum of one manhole of the size indicated (or maximum size possible) shall be provided for each transformer.

For transformers above 12.5MVA three-phase there shall be more than one manhole in the transformer cover to facilitate the removal and installation of bushings and current transformers, tap changer mechanisms, winding temperature current transformers, etc., and to provide access to the terminal board without disturbing the leads. Manholes, if circular, shall be a minimum of 600mm in diameter. If rectangular or oval, they shall have minimum dimensions of 600 x 450mm. All manhole covers shall be placed on gaskets, which shall be

confined in recesses machined in the tank flange or the lower side of the cover. All joints of oil-filled fabricated chambers, other than those, which have to be broken, shall be welded and care shall be taken to ensure that the chambers are oil-tight.

Defective welded joints shall not be caulked but may be rewelded subject to the written approval of the Engineer. Oil filling level indication shall be engraved on the inside and outside of the chambers.

All joint faces are to be machined flat and parallel and arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil-resisting synthetic rubber gaskets are not permissible unless the degree of compression is accurately controlled. For gaskets of cork or similar, oil resisting synthetic rubber may be used as a bonding medium. The gasket should be suitable for site condition described in the Basic Design Parameters. The gaskets shall be at least 3mm thick when compressed. All mounting bolts shall be external to the gasket.

The tank and conservator (if required) shall be designed to withstand and hold continuously a vacuum of 760 mm Hg. To avoid any gas pockets, the inside surface of the covers shall be flushed with that of the tank internals. Special precautions shall be taken to ensure that any gas evolved is directed as quickly as possible to the gas detector relay. The tank covers shall be slanted or domed away from the direction of the major axes to prevent gas from being trapped at the ends or sides of the tank cover. The gas collection point shall be located at the 'high spot' of the cover.

Core and Coils

Cores and coils shall be braced to withstand the short circuit forces without damage or displacement of the coil on the core, and to withstand normal moving and handling without the use of special shipping braces.

Suitable cooling liquid passages shall be provided to limit the hot spot temperature rise above the average winding temperature rise at rated load to those values specified in IEC 60076.

Lifting lugs shall be included to facilitate removal of the complete core and coil assembly for repairs.

The current carrying capability of the transformer shall be limited only by the capacity of the core and coils, not by the capacity of other current carrying components such as bushings and tap changers.

Transformer Coil Windings

The full installation shall be applied on both Primary (phase & neutral) and Secondary windings and neutral point shall be solidly grounded.

Transformer coil windings shall be high-conductivity copper and transposed winding conductors shall be employed where appropriate. The coils shall be insulated from the core and each other with the sufficient insulation to withstand the specified impulse and low frequency dielectric tests for transformers of the specified voltage class. Insulating media shall be of Class A as designated in IEC 60085.

Winding of coils shall be designed so as to make the initial potential distribution caused by impulsive travelling waves as uniform as possible, to avoid potential oscillation and to withstand abnormal voltage due to switching.

The insulation shall be designed not merely by normal voltage per turn, but also by variation of line voltage and the operating conditions including impulse surge caused by lightning strokes on the transmission line and switching surges.

The windings shall be constructed such that to facilitate effective cooling by natural oil circulation. Where forced and directed oil cooling method are specified, the arrangement of the oil ducts and oil flow washers shall be such that to ensure significant oil flow rate and thus cooling in all parts of the windings.

Where tertiary windings are required, they shall be provided by the Contractor. The product of the number of turns of the tertiary windings and the cross-sectional area of one such turn shall not be less than 33% of the corresponding product for the main winding at nominal ratio. They shall be designed to withstand without injury the effects of short circuits on the tertiary or other windings up to the specified short circuit capabilities.

where tertiary windings are not specified, but are required, a stabilizing winding or "buried" tertiary can be provided. On three phase units one corner of the "buried" or stabilizing winding shall be provided with two



removable test links, one to open the delta and the other to open the ground connection. These links shall be located inside the transformer tank and shall be easily accessible through a manhole in the tank cover.

Transformer Cores

Frame and core bolts shall be insulated from the core. The cores, framework and clamping arrangements shall be capable of withstanding any shocks to which the transformers may be subjected. Movement of the transformer core relative to the tank shall be prevented.

Care shall be taken to maintain even mechanical pressure over the whole of the laminated core. Each lamination shall be insulated with a material, which shall not deteriorate under pressure and the action of hot oil.

Core oil ducts shall be provided where necessary to ensure adequate cooling. The winding structure and main insulation shall not obstruct the flow of oil through such ducts.

Where the magnetic circuit is divided into packets separated by more than 0.25mm by cooling ducts parallel to the plane of the laminations or by insulating material, tinned copper-strip-bridging pieces shall be inserted to maintain electrical continuity between the packets.

All metal parts of the transformer, except individual core laminations, core bolts and side clamping plate shall be maintained at earth potential. The magnetic circuit shall be earthed to the clamping structure through one removable core-insulation test link only, placed in an accessible position beneath an inspection opening in the main tank cover.

Insulating oil

The transformer shall be provided with the necessary amount of high-grade mineral insulating oil in accordance with the IEC 60296 (Class I) standard and comply to the Employer's current practice. Tests shall be made in the Engineer's/Employer's presence to prove that the breakdown voltage shall be at least 50kV.

The insulating oil shall have sufficient insulation strength, and shall be excellent in heat conductivity, low in viscosity and pour point, and high in flash point. The oil shall not cause any corrosion to insulating materials and structured materials of electrical equipment and shall be chemically stable for long years of use.

Delivery shall be made to site partly contained in the transformers and partly in steel drums, according to the method of packing employed. An excess of 10% of the quantity of oil required for filling transformers shall also be supplied and its cost shall be included in the price of each transformer.

Where possible, the transformer shall be shipped filled with the oil. If the transformer cannot be shipped filled with oil it shall be filled with nitrogen or dry air in accordance with the manufacture's proven standard procedures. The initial filling of the transformer shall be made under acceptable methods designed to eliminate entrained air and moisture from within the tank and windings.

Transformer oil collecting pit shall be provided surrounding the transformer foundation.

The pit shall have capacity to collect all volume of oil in the tank.

Oil Preservation System

Transformer shall have an oil preservation system for protecting the oil against atmospheric moisture and oxygen. The oil preservation system of each transformer shall be of diaphragm seal or air seal cell type conservator with silica-gel breather. Inert gas systems, "sealed tank" systems or conservator systems shall each conform to their respective requirements.

Oil Conservator Systems

Oil conservator-type preservation systems shall be complete with filling cap, sump and drain valve and having adequate capacity for the ambient temperature range at the Site.

The capacity between the highest and lowest visible levels shall not be less than 7.5% of the total cold oil volume in the transformer and cooling equipment.

The tank shall be mounted with a 25mm slope between the ends to facilitate draining and the lower end shall be fitted with a 25mm drain/filter press valve complete with dummy plug. The conservator shall be provided with a manhole, 50mm filling valve with dummy plug and lifting eyes.

The connecting pipe to the main transformer tank shall be provided with an indicating shut-off valve located on the conservator side of the gas detector relay. The shut-off valve shall have a lever to indicate "valve open" when in line with the pipe and "valve closed" when at right angles to the pipe. The "open and "closed" positions of the handle shall be easily observable from ground level. The handle shall be arranged so that it can be attached in only one way.

The main oil feed pipe from the conservator to the transformer shall be connected to the highest point of the transformer tank and shall be arranged at a rising angle towards the conservator of from 3 to 7 degrees to the horizontal and shall have a minimum internal diameter of 75mm. Sharp bends in the pipe work shall be avoided.

The oil preservation system shall be such that there is no continuous contact between the oil in the conservator and the atmosphere. A dehydrating breather containing a color indicator shall be piped to the conservator and mounted at eye level.

A dehydrating type of breather, by itself, is not acceptable; either of the following methods may be used.

On Load Tap Changer

The transformer shall be provided with an on-load tap changer where specified and shall be preferably of proven make.

The On-load tap changer shall comply with all applicable portions of the latest issue of IEC 60214 unless otherwise specified.

The On-load tap changer shall be provided with all necessary equipment mounted at the transformer for manual operation. The equipment shall include a manual "Lower-Raise" control switch and rotating synchronous flush mounted tap position indicators for local control at the transformer.

The On-load taps shall be controlled by motor operated equipment to proven reliability and requiring a minimum of maintenance.

Overload and short-circuit characteristics shall be compatible with those of the transformer. All taps shall be rated for full capacity.

All On-load tap changer components shall be designed for the full continuous rating of the transformer. The drive mechanism shall be designed so that it is impossible for the tap change to stop in any non-fully rated position. This shall apply whether the tap changer is driven by the motor or by manual hand operation.

The tap changer operation shall start on a "Raise" or "Lower" impulse of short duration and shall "seal-in" and complete the step by itself. The duration of a signal beyond the time required for

operation shall not initiate a second operation. In the event of a power failure during a tap change operation, the tap changer shall automatically complete its operative to the next upper or lower tap position as soon as power returns. The return of power shall not initiate a second operation.

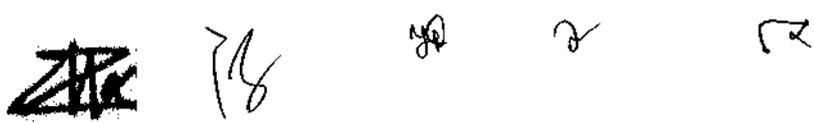
Electrical limit switches and mechanical stops or de-clutching devices shall be incorporated to prevent over-travel beyond the maximum raise and lower positions.

Electrical and mechanical interlocks shall be provided on the "Raise" and "Lower" contractors.

Tap changer motor protection shall consist of an over current automatic air circuit breaker with manual reset, or alternatively, a contractor with an isolating device, fuses and single phasing protection. An alarm shall be provided for operation of any motor protective devices.

The diverter switches shall be located in a separate compartment especially for 132/33kV transformers so that the oil is completely isolated from the main transformer oil. It shall be possible to drain and sample the oil from this compartment for maintenance purposes without lowering the oil in the main transformer compartment.

Each tap changer oil-filled compartment shall be provided with a magnetic oil level gauge with low-level alarm contacts, pressure relief device, filling/filter press valve and rain/filter press valve. The diverter switch compartment shall also be provided with a fault pressure relay with auxiliary contacts or, alternatively,

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auxiliary contacts may be provided on the pressure relief device. A dehydrating type of breather shall be provided mounted at eye level.

The breather shall contain a color indicator and shall be of a type in which the desiccant is not in continuous contact with the atmosphere.

When the design of tap changer requires an oil expansion tank, it shall be piped to the main transformer conservator. It shall preferably be piped to a separate compartment in the conservator although it may be piped to the transformer compartment if an approved filter is provided in the tap changer to conservator oil connection pipe. If piped to a separate compartment the compartment shall be provided with its own magnetic oil level gauge with low level alarm contacts, filling/filter press valve and drain valve. A fault pressure relay with auxiliary contacts shall be provided in the pipe to the conservator. A shut-off valve shall be provided in the conservator pipe, on the conservator side of the fault pressure relay.

All oil level gauges shall be legible from ground level. Filling and drain valves shall be not less than 25mm complete with dummy plugs.

Reservoir with sufficient capacity shall be provided to collect transformer oil that is discharged accidentally. The reservoir shall be reinforced concrete structure with oil water separator. Transformer oil tank shall be connected to the reservoir by welded steel pipes.

2.4.1.2.23 132kV GIS Switchgear 132kV GIS

General

The contractor shall furnish the 132kV indoor GIS switchyard equipment which shall comply with relevant IEC as listed below and the 132 KV equipment shall be arranged in the indoor as shown on the attached drawings.

Design Equipment

- System voltage

The system shall be as follows:

- ◇ Nominal system voltage: 132 kV
- ◇ Highest system voltage: 145 kV
- Insulation level

The insulation level of the switchgear, equipment shall be as follows:

- ◇ Lighting impulse withstand test 650 kV (Peak)
- ◇ Voltage (1.2/50 micro sec.)
- ◇ Power frequency insulation level (for 1 mm.) :275kV
- Outdoor Conductor Clearance
- ◇ Minimum clearance between live metal parts and earth: 1300 mm
- ◇ Minimum clearance between live metal: 1500 mm
- Design Conditions

Switchgear equipment shall be designed to avoid local corona formation and discharge likely to cause radio interface, and to endure short circuit current without thermal and mechanical failure for one (1) second. All cubicles and enclosures shall be vermin proof, dust resistance and weatherproof.

132kV Circuit Breakers

- Type

Three (3) pole, porcelain type, high speed, outdoor, trip free in any position, hydraulic & spring-operated SF gas puffer, single flow type complete with hydraulic pump, tank, piping, conduit, wiring, and all other necessary accessories.

- Use

For paralleling, control, and protection.

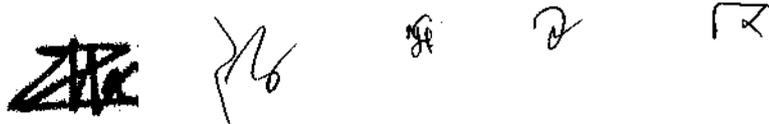
➤ Ratings

- ◇ Rated voltage: 145 kV
- ◇ Rated frequency: 50Hz
- ◇ Rated transient recovery voltage for terminal faults and rated characteristics for short line faults shall be in accordance with IEC56.
- ◇ Rated operating time: Less than 40 m sec
- ◇ Rated operating sequence (<2.5 cycles): O-0.3sec-co-3min-co.

➤ Control System

The rated supply voltages of closing and opening devices shall be 220V DC, and the operation of circuit breaker shall be performed safely under the following conditions:

- ◇ For tripping operation (-30% to +10%): 154Vto 242VDC
- ◇ For closing operation (-15% to+10%): 187V to 242V DC
- ◇ The rated hydraulic pressure shall be recommended by the Contractor.
- ◇ Requirements for Design and Construction
- ◇ The circuit breakers shall have automatic trip free mechanism.
- ◇ Time difference between contacts of three (3) poles shall not be more than 0.006 sec.
- ◇ In case of phase open trouble, all phases of the circuit breaker shall be opened by a protection circuit.
- ◇ The arcing contact shall be of an arc proof metal and the main contact shall be covered
- ◇ with silver electroplated.
- ◇ Five (5) pairs of "a-b" spare contacts shall be equipped with the auxiliary switches.
- ◇ The tripping current of the trip coil shall not be more than 2A per phase.
- ◇ Shall be able to withstand stresses due to breaker operation.
- ◇ The glazing color shall be of brown.
- ◇ The creepage distance shall not be less than 25mm /kV of phase-to-phase voltage.
- ◇ Integrating time register for hydraulic pump shall be driven by a self-starting synchronous motor through mechanical gears to record operating hours of hydraulic pump and shall be able to perform four operations without AC power.
- ◇ Gas circuit breaker shall be provided with gas density detector responding to gas density
- ◇ and pressure. This gas density detector shall have two (2) different functions according to the gas condition: The first step gives alarm and the second step locks the operating mechanism.
- ◇ Operating mechanism which employs compressed air or hydraulic for driving the circuit breaker shall be provided with pressure detector which have two (2) different functions according to compressed air or hydraulic condition: The first step gives alarm and the 2ndstep locks the operating mechanism.
- ◇ The weather and dust proof type control box shall be furnished with the circuit breakers. The control box shall be equipped with all necessary parts to operate the circuit breaker, such as control solenoids, operating switch of remote and local control, auxiliary switch, terminal blocks, protective devices, indicating lamp sockets, and other accessories. An anti-condensation electric heater with thermostatic switch shall be provided inside the control box.
- ◇ The circuit breakers shall be provided with an emergency push button switch with cover to prevent inadvertent switching.

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- ◇ The circuit breakers shall be provided with an electrical anti pumping relay.
- ◇ The supporting structure shall be free from mechanical vibration and loosening under long term use.
- ◇ The circuit breakers shall be designed to facilitate inspection, especially for those parts
- ◇ which need inspection frequently.
- ◇ The circuit breakers shall be filled with sufficient SF6 gas.
- ◇ The circuit breakers shall be driven by hydraulic, and spring charged. Hydraulic supplying system shall be furnished with the circuit breakers and shall be installed in weather dustproof type housing. The operating mechanism shall be designed to meet the requirements of IEC 56
- ◇ Temperature limitation shall be in accordance with IEC62271-100.
- ◇ The Contractor shall furnish all control cables, pipes or ducts and fittings between each phase and control box.
- ◇ The Circuit Breakers shall be provided with isolators on either side.

132kV Disconnecting Switches

➤ Ratings

- ◇ Rated voltage :132kV
- ◇ Rated insulation level.

- lighting impulse withstand test voltage :650kV (peak)

- Power frequency withstand voltage (for 1 mm.): 275kV

- ◇ Rated frequency :50Hz

➤ Requirements for Design and Construction

- ◇ The disconnecting switches shall be so designed and constructed in accordance with IEC129.
 - ◇ The contact part of the blade shall be silver electroplated.
 - ◇ The porcelain insulator shall be an outdoor and post type and shall have creepage distance not less than 25 mm / kV of phase-to-phase voltage age. The glazing color shall be of brown.
 - ◇ An electrical or mechanical interlocking device shall be equipped between its related circuit breakers.
 - ◇ Revolving parts shall be so designed that operation will be sure and smooth under long
 - ◇ term use without necessity of inspection, oiling.
 - ◇ Auxiliary switches with three (3) spare parts "a-b" contacts, terminal blocks, indicator lamp sockets, etc. shall be accommodate in a control box shall be of the weather and dustproof type with locking device.
- ##### ➤ Dielectric Test voltage
- ◇ Power frequency withstand voltage:275kV for one minute
 - ◇ Lighting impulse withstand voltage - Full wave (1.2/50 micro sec.): 650 kV Peak
 - ◇ Test voltage on control circuit :2.0kV for one min

132kV Voltage Transformer

➤ Type

Outdoor , single phase, oil immersed with level indicator or gauge,N2 gas sealed Electromagnetic type voltage transformer.

- Use
- For metering and protection
- ◇ Primary: 132/√3 kV

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- ◇ Secondary: $110\sqrt{3}$ kV
- ◇ Tertiary: $110\sqrt{3}$ kV
- Ratings
- ◇ Rated frequency :50 Hz
- ◇ Accuracy class :0.5 (secondary):3 P (tertiary)
- ◇ The voltage transformers shall be of hermetically sealed and accessories shall be of weatherproof type.
- ◇ The glazing color shall be of brown.
- ◇ A protection device shall be provided against short circuit of the secondary circuits of the voltage transformers.
- ◇ Unless otherwise specified, the characteristic and others shall comply with the requirements of IEC186.
- Accessories

The following accessories shall be provided for each voltage transformer:

- ◇ Nameplates.
- ◇ Grounding terminals.
- ◇ Lifting lugs.
- ◇ Steel supporting structure with anchor bolts and nuts.
- ◇ Junction boxes.
- ◇ Conduit pipes (Steel/GI).
- ◇ Other necessary accessories if any

132kV Current Transformers

- Type

Outdoor , single phase, oil immersed with level indicator or gauge, N₂ gas sealed porcelain clad type, quadruplicate cores.

- Use

For metering and protection

- Ratings
- ◇ Rated frequency :50 Hz
- ◇ Rated continuous thermal current :120%
- ◇ Accuracy classes
- ◇ For metering :0.2,n<5.
- ◇ For protection :5P30
- Requirements for Design and Construction

- ◇ The current transformer shall be of oil immersed hermetically sealed structure type. Internal conductor shall be adequately reinforced taking into account over current intensity.
- ◇ The junction box with terminals shall be provided for the secondary circuit connections.
- ◇ Each current transformer shall be equipped with terminal block of short-circuiting type.

- ◇ Creepage distance of bushing shall not less than 25 mm/kV of phase-to-phase voltage.
- ◇ The glazing color shall be of brown.
- ◇ Unless otherwise specified, the characteristics and others shall comply with IEC185

132kV Lightning Arresters

➤ Type

Outdoor, single phase, self-standing, Metal-Oxide type with surge operating counter.

➤ Use

For protection of 132 KV outdoor switchyard equipment and transformer windings.

➤ Electric system to be protected

Three (3) phase, three (3) wire, neutral point solidly grounded system.

➤ Ratings and Performances

- ◇ Rated voltage: 186 kV
 - ◇ Rated frequency: 50Hz
 - ◇ Nominal discharge current :10 kA
 - ◇ Type of duty: Heavy, Long duration discharge
 - ◇ Pressure relief class: c
 - ◇ Maximum residual voltage: 400 kV
 - ◇ Power frequency spark-over voltage: 170 kV
- ##### ➤ Operating duty

The arrester shall successfully interrupt the dynamic current repeatedly conducted by impulse wave.

➤ Requirements for Design and Construction

- ◇ The series gaps shall be so designed that for practical purposes the various characteristics will not alter under the change of weather conditions.
- ◇ The various parts of the lightning arrester shall be of complete moisture proof construction so that the characteristics shall not be impaired under long term use. Sealed parts shall be so designed to prevent to ingress of moisture or water under long term use.
- ◇ The operation counter shall be equipped on the lightning arrester in each phase and consist of a sure current recording and measuring device, such as a magnetic link surge crest ammeter, and counter for the number of discharges of the lightning arrester. It shall be located at the position convenient for inspection.
- ◇ Creepage distance of bushing shall not be less than 25 mm/kV of phase-to-phase voltage.
- ◇ The glazing color shall be of brown.
- ◇ Unless otherwise specified, the characteristics and others shall comply with IEC 60099-1.

➤ Accessories

The following accessories shall be provided for each lightning arrester.

- ◇ Nameplates.
- ◇ Grounding conductor to grounding terminal.
- ◇ Operating counter.
- ◇ Grounding terminal.
- ◇ Steel supporting structure with anchor bolts and nuts.
- ◇ Other necessary accessories, if any.

2.4.1.3 132kV Transmission Line

2.4.1.3.1 General

The Contract shall comprise design, manufacturing, testing, supply, insurance, delivery to site of towers, poles, phase conductors, earthwire, OPGW including all associated fittings, complete insulator sets, phase and earthwire tension and non-tension joints and clamps, vibration dampers, erection, setting to work, testing and the replacement and/or adjustment of defective material and workmanship for the duration of the warranty period as:

1(one) 132kV double circuit transmission Line from Moheshkhali Solar Plant to Matarbari 132kV Grid Substation. The transmission line shall have 2(two) bays on either side: two bays at PV Plant substation and two bays at Matarbari 132kV Grid Substation.

The second 132kV transmission line from Matarbari 132kV Grid Substation to Chakoria Grid Substation. The transmission line shall have 1(one) bay on either side: 1(one) bay at Matarbari 132kV Grid Substation and 1(one) bay at Chakoria Grid Substation.

The specification of 132kV transmission line like survey, design, foundation, towers, insulators, conductors, earthwires, fittings, dampers, OPGW, aircraft navigation etc, shall follow the standard and code and any other requirement issued by PGCB.

2.4.1.3.2 Scope of Works

(1) Detailed survey including route alignment, profiling, tower spotting, optimization of tower locations, soil resistivity measurement & geotechnical investigation (including special foundation locations, viz.pile/well foundation locations, if any).

(2) Check survey shall be conducted to Locate tower locations on ground conforming to the approved profile and tower schedule.

(3) Fabrication,testing and supply of all types of transmission line towers including stubs, fasteners, anti-theft fasteners, step bolts, hangers, D-shackles, number plate, danger plate, tower earthing,etc.

(4) Fabrication,testing and supply of all types of tower accessories such as phase plates,circuit plates(wherever applicable), number plates,danger plates,anti-climbing devices, bird guards, ladders(wherever applicable), resting platforms (wherever applicable), etc.

(5) Design, manufacture, testing and supply of hardware fittings and Conductor & OPGW accessories. Supply of conductors, insulators, OPGW from PGCB store. Relevant price is deemed to be included in the price schedule.

(6) Compensation costs (if any) related to the construction of the transmission line shall be borne by the Contractor.

2.4.1.3.3 Details of Transmission Line Routes and Terrain

The detailed survey shall be carried out using Total stations, DGPS, etc. along the route. As an alternative the Contractor may also use ALTM(Airborne Laser Terrain Modelling) techniques of equal or better accuracy for the detailed survey.

Bidders may however visit the line route to acquaint themselves with terrain conditions approach/accessibility to the site, salient features of the route and associated details of the proposed transmission lines.

2.4.1.3.4 Location Details and Terminal Points

The transmission line shall connect the Moheshkhali Solar Plant to Matarbari 132kV Grid Substation, and connect Matarbari 132kV Grid Substation to Chakoria Grid SubStation. For this the Contractor shall construct connecting bays on either side of the transmission lines:2(two) bays at PV plant substation, 3(three) bays at Matarbari 132kV Grid Substation and 1(one) bay at Chakoria Grid Substation.

Phase conductors and earthwires shall be terminated at the gantry structures of the substations. OPGW termination boxes shall be installed at the base of the substation's gantry structures.

A jumper of sufficient length shall be provided with the slack span to be terminated at the substation entry equipment.

2.4.1.3.5 Estimated and Final Quantities

The quantities set out in the schedules are, unless otherwise defined, estimated quantities of the Works required. They are not to be assumed as the actual and final quantities to be executed by the Contractor and fulfilment of his obligations under the contract.



Final quantities are to be established by the Contractor, and agreed upon by the Employer immediately after signing of the Contract, after the selection of tower positions has been made on completion of the survey of the transmission line routes.

2.4.1.3.6 Modifications

The transmission lines shall be completely in accordance with the Specification and associated design and general arrangement/outline drawings. Any modifications shall be subjected to written confirmation by the Employer/Engineer.

2.4.1.3.7 Programme of Work

Within 4(four) weeks of signing of the Contract the Contractor shall submit to the Employer for approval, bar chart detailing the plant manufacture, testing, delivery and erection programme(as appropriate) for the complete Contract Works.

The bar chart shall indicate the various phases of work for all appropriate items of the Contract, from commencement of the Contract to its final completion e.g. design, survey, approval of drawings, ordering of materials, manufacture, testing, delivery, erection and commissioning. The bar chart shall, when appropriate, allow the requisite periods of approval by the Employer, and/or any other regulatory body.

If at any time during the execution of the contract it is found necessary to modify the approved bar chart, the Contractor shall inform the Employer and submit a modified bar chart for approval. Such approval is not deemed to be consent to any amendments to the contractual completion date(s).

Modifications that may affect site work and associated local arrangements must provide a sufficient notice period to allow for any necessary re-arrangements. It should be recognised that where certain power line outages for crossing purposes have been specified, it may not be possible for these to be replanted due to system operational constraints and this should be allowed for in the overall programme.

The Employer intends that access will be given to a reasonable number of sites to provide continuity of work. However, the Contractor shall accommodate reasonable delays in access to some individual sites that may prevent sequential foundation installation and support erection work being carried out. Provided he has overall continuity of work this shall not affect the Contractor's programme.

2.4.1.4 Expansion work of Matarbari 132/33kV Grid Substation

The 132kV interconnection transmission lines shall be connected to existing Matarbari 132kV Grid Substation and Chakoria Grid Substation. Four(4) 132kV bays and related protection, control, metering, SCADA system shall be done in the bidder's scope.

2.4.1.5. Right of Way & Terminal Points:

- a. Construction of 132KV double circuit evacuation line from project site to Matarbari Grid Substation.

Phase conductors and one OPGW shall be terminated at the gantry structures of Matarbari Grid Substations (all transmission lines). OPGW termination boxes shall be installed at the base of the substation's gantry structures.

A jumper of sufficient length shall be provided with the slack span to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of this project.

- b. Stringing of the second circuit on the existing 132 kV Maheskhali-Chakaria transmission line, including installation of OPGW. Phase conductors and one OPGW shall be terminated at the gantry structures of Chakoria and Matarbari grid Substations. OPGW termination boxes shall be installed at the base of the respective substation gantry structure.

A jumper of sufficient length shall be provided with the slack span to be terminated at the substation entry equipment. The termination work of the jumper to the substation equipment is not scope of EPC contract.

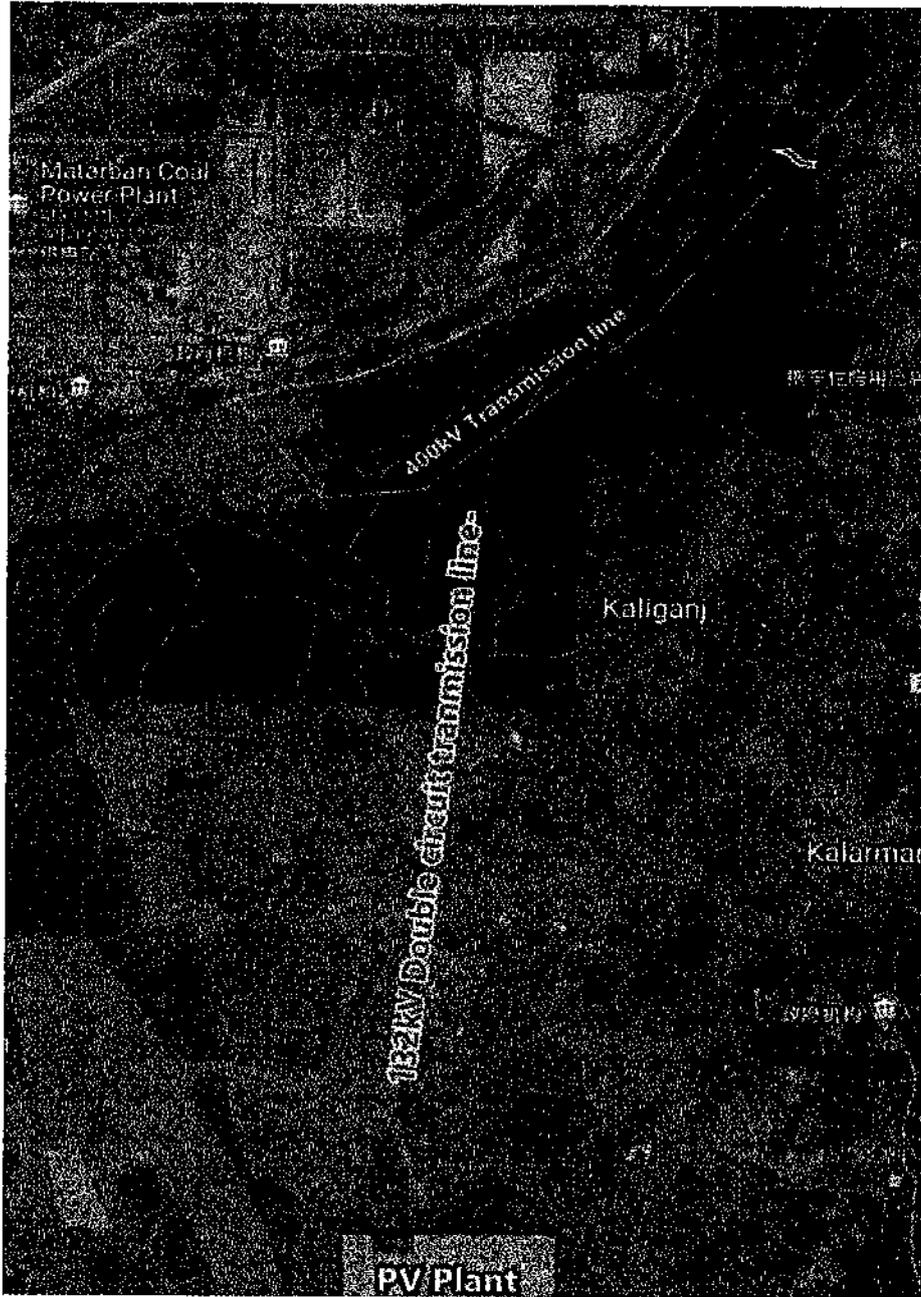


Figure : 132KV Double Circuit Transmission line Right of Way from Solar PV Substation to 132KV Matarbari Grid Substation

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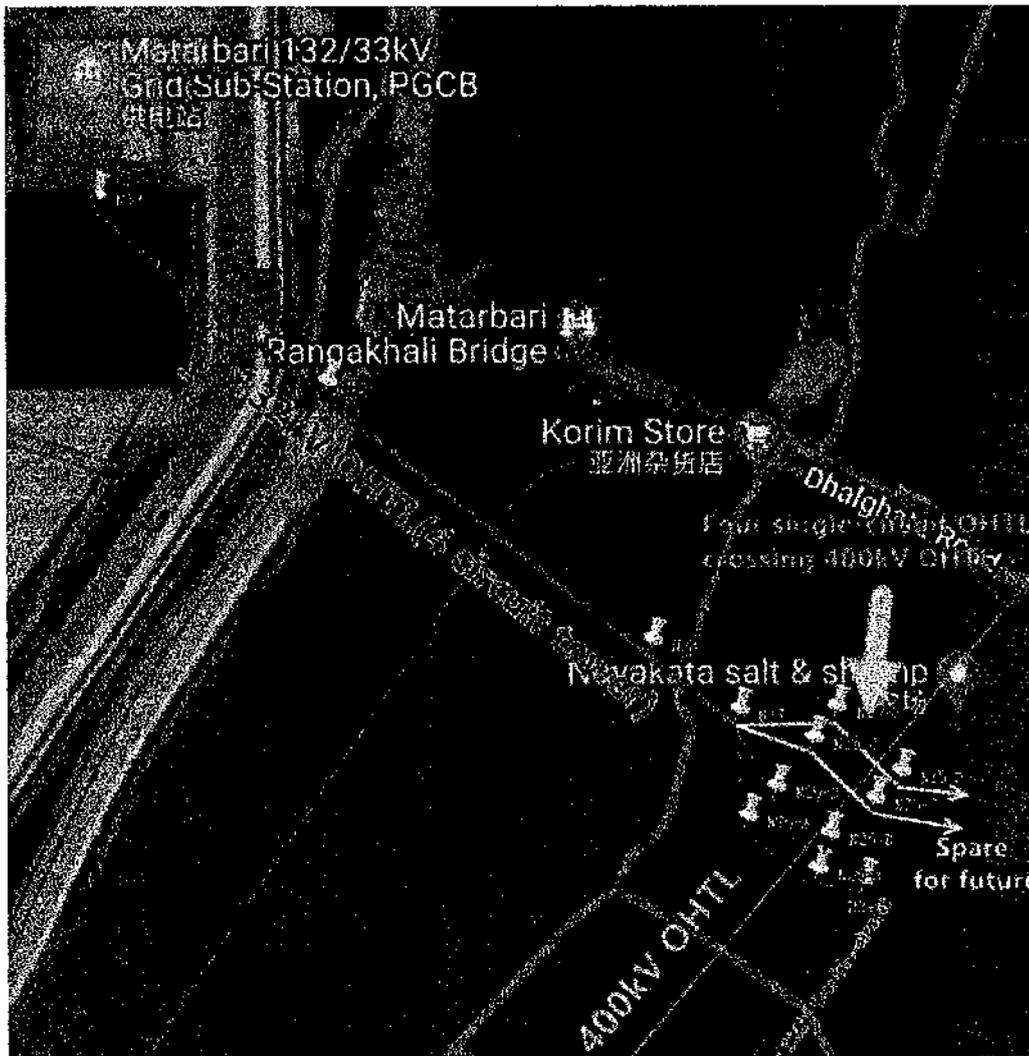


Fig: 132KV Four Circuit Transmission line Right of Way

Co-ordination of the transmission line towers from Solar Project Site to 132KV Matarbari Grid Substation

塔号 Tower No.	纬度 Latitude	经度 Longitude	备注 Remarks
N1	21°39'24.9"	91°53'49.0"	Double-circuit tower
N2	21°39'31.8"	91°53'46.8"	Double-circuit tower
N3	21°39'38.4"	91°53'44.6"	Double-circuit tower
N4	21°39'47.1"	91°53'45.1"	Double-circuit tower
N5	21°39'55.7"	91°53'45.7"	Double-circuit tower
N6	21°40'4.5"	91°53'46.3"	Double-circuit tower
N7	21°40'13.6"	91°53'46.9"	Double-circuit tower
N8	21°40'22.2"	91°53'47.5"	Double-circuit tower

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N9	21°40'31.0"	91°53'48.7"	Double-circuit tower
N10	21°40'39.9"	91°53'50.0"	Double-circuit tower
N11	21°40'49.1"	91°53'51.3"	Double-circuit tower
N12	21°40'58.1"	91°53'52.6"	Double-circuit tower
N13	21°41'7.9"	91°53'54.1"	Double-circuit tower

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塔号 Tower No.	纬度 Latitude	经度 Longitude	备注 Remarks
N14	21°41'17.1"	91°53'55.4"	Double-circuit tower
N15	21°41'25.6"	91°53'56.6"	Double-circuit tower
N16	21°41'30.5"	91°54'3.3"	Double-circuit tower
N17	21°41'36.2"	91°54'11.0"	Double-circuit tower
N18	21°41'41.2"	91°54'17.9"	Double-circuit tower
N19	21°41'47.0"	91°54'25.7"	Double-circuit tower
N20	21°41'52.3"	91°54'33.0"	Double-circuit tower
N21	21°41'57.8"	91°54'40.6"	Double-circuit tower
N22	21°42'6.2"	91°54'46.5"	Double-circuit tower
N23	21°42'14.6"	91°54'52.4"	Double-circuit tower
N24	21°42'20.7"	91°54'56.7"	Double-circuit tower
N25-A	21°42'21.0"	91°54'55.3"	Single-circuit tower
N25-B	21°42'22.0"	91°54'55.6"	Single-circuit tower
N25-C	21°42'23.0"	91°54'57.0"	Single-circuit tower
N25-D	21°42'23.8"	91°54'57.9"	Single-circuit tower
N26-A	21°42'22.5"	91°54'53.1"	Single-circuit tower
N26-B	21°42'23.4"	91°54'54.0"	Single-circuit tower
N26-C	21°42'24.8"	91°54'55.2"	Single-circuit tower
N26-D	21°42'25.7"	91°54'55.9"	Single-circuit tower
N27	21°42'25.6"	91°54'52.9"	Four-circuit tower
N28	21°42'27.6"	91°54'50.2"	Four-circuit tower
N29	21°42'35.1"	91°54'40.2"	Four-circuit tower
N30	21°42'40.5"	91°54'33.1"	Four-circuit tower

Types of Tower and Insulators:

Tower No.	Tower Type	Angle deviation	Description	Insulator type	Insulator Quantity	Conductor	Remark
N1	IDL	0°	Intermediate	Suspension – Single 70kN	60	ACSR Grosbeak	Double Ckt
N2	IDL	0°	Intermediate	Suspension – Single 70kN	60	ACSR Grosbeak	Double Ckt
N3	1D25	20°	Angle	Tension Single 120kN	132	ACSR Grosbeak	Double Ckt
N4	IDL	0°	Intermediate	Suspension – Single 70kN	60	ACSR Grosbeak	Double Ckt
N5	IDL	0°	Intermediate	Suspension – Single 70kN	60	ACSR Grosbeak	Double Ckt

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N6	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N7	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N8	1D25	8°	Angle	Tension Single 120kN	132	ACSR Grosbeak	Double Ckt
N9	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N10	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N11	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N12	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N13	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N14	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N15	1DT6	44°	Angle Terminal	Tension Single 120kN	132	ACSR Grosbeak	Double Ckt

Section 6 – Employer’s Requirements (ERQ)

Tower No.	Tower Type	Angle deviation	Description	Insulator type	Insulator Quantity	Conductor	Remark
N16	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N17	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N18	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N19	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N20	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N21	1D25	19°	Angle	Tension Single 120kN	132	ACSR Grosbeak	Double Ckt
N22	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N23	IDL	0°	Intermediate	Suspension - Single 70kN	60	ACSR Grosbeak	Double Ckt
N24	2D9	110°	Angle	Tension Single 120kN	132	ACSR Grosbeak	Double Ckt
N25-A	2Q30	23°	Angle	Tension Single 120kN	66	ACSR Grosbeak	Single Ckt
N25-B	2Q15	9°	Angle	Tension Single 120kN	66	ACSR Grosbeak	Single Ckt
N25-C	2Q30	29°	Angle	Tension Single 120kN	66	ACSR Grosbeak	Single Ckt
N25-D	2Q30	27°	Angle	Tension Single 120kN	66	ACSR Grosbeak	Single Ckt
N26-A	2QT6	50°	Angle	Tension Single 120kN	66	ACSR Grosbeak	Single Ckt
N26-B	2Q30	22°	Angle	Tension Single 120kN	66	ACSR Grosbeak	Single Ckt
N26-C	2Q30	27°	Angle	Tension Single 120kN	66	ACSR Grosbeak	Single Ckt
N26-D	2QT6	48°	Angle	Tension Single 120kN	66	ACSR Grosbeak	Single Ckt
N27	1QT6	48°	Angle	Tension Single 120kN	264	AACSR	Four Ckt
N28	1QL	0°	Intermediate	Suspension - Single 70kN	120	AACSR	Four Ckt
N29	1QL	0°	Intermediate	Suspension - Single 70kN	120	AACSR	Four Ckt

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N30	1QL	0°	Intermediate	Suspension - Single 70kN	120	AACSR	Four Ckt
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Types and quantity of Conductors:

- Total required ACSR Grosbeak Conductor - 99 km
- Total required AACSR (river crossing) Conductor - 25 km

2.4.1.6. Climatic Conditions

The climatic conditions associated with the site are summarised below. However, it is advised to make a thorough study of local climatological records, since no delays to the completion dates due to adverse weather conditions shall be accepted. All plant and equipment supplied under the contract shall be entirely suitable for the climatic conditions prevailing at site.

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The project area and vicinity is close to sea level and is in a tropical climate. The ambient shade temperature variation is between 4 °C and 45 °C with periods of high humidity.

Between May and November, low-lying areas are subject to flooding. Flooding countermeasure shall be taken for the civil design, so as not to affect any equipment or works during the wet season. As per the recorded past maximum flood water levels in the project area, sufficient ground level height for land formation is required at the Contractor’s responsibility.

The project area is a designated zone of moderate earthquake intensity. The seismic factor is 0.28 g. Atmospheric pollution is moderate and no special insulator design or washing is required. The area is subject to high winds of typhoon strength.

Description	Unit	Required
Maximum ambient shade temperature	°C	45
Minimum ambient shade temperature	°C	4
Maximum daily average temperature	°C	35
Everyday temperature for design (EDT)	°C	30
Maximum annual average temperature	°C	25
Maximum wind velocity for line design purposes	km/h	refer to tower section
Minimum wind velocity for line rating purposes	km/h	3.2
Solar radiation	W/m ²	1000
Rainfall	mm/year	2500
Relative humidity, maximum	%	100
Relative humidity, average	%	80
Altitude	m	< 1000
Atmospheric pollution	-	medium
Icing	-	no ice or snow expected
Seismic factor	g	0.28
Soil type	-	alluvial
Soil temperature (at 1.1 m)	°C	30 °C at 1.1 meter depth
Soil thermal resistivity	°Cm/W	1.5
Isokeraunic level (thunderstorm days/year)	days/year	80

The information in this para is given solely for the general assistance of Bidders and no responsibility for it will be accepted nor will any claim based on this para be considered.

2.4.1.7. Acceptance Criteria and Permissible Limits for Cement

2.4.1.7.1 Mechanical and physical requirements given as characteristic values

Strength Class*	Early Strength		Standard Strength	Initial Setting Time	Soundness (m)
	2 days	7 days	28 days		
32.5N	-	≥ 16.0	≥	≥	
32.5R	≥ 10.0	-	32.5	75.0	
42.5N	≥ 10.0	-	≥	≥	≤
42.5R	≥ 20.0	-	42.5	60.0	10.0
52.5N	≥ 20.0	-	≥	≥	
52.5R	≥ 30.0	-	52.5	45.0	

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R

2.4.1.7.2 Chemical requirements given as characteristic values

Property	Strength Class*	Requirements
Loss on ignition	All	= 5.0%
Insoluble residue	All	= 5.0%
Sulphate content	32.5N	= 3.5%
	32.5R	
	42.5R	= 4.0%
	52.5N	
Chloride content	All	= 0.1%

* A class with ordinary early strength, indicated by N and a class with high early strength indicated by R.

The requirements are not limited to those mentioned above. For details of the requirements please refer to BS EN 197-1.

2.4.1.7.3 Acceptance Criteria and Permissible Limits for Reinforcement Steel

	Carbon Steel Bars as per BS 4449			
	Grade 250	Grade 460		
i)	Chemical analysis test			
	Carbon	0.25% max.	0.25% max.	
	Sulphur	0.06% max.	0.05% max.	
	Phosphorus	0.06% max.	0.05% max.	
ii)	Physical tests			
	Specified characteristic strength	250 N/mm ²	460 N/mm ²	Testing in approved lab
	Minimum elongation	22%	12%	Testing in approved lab
iii)	Bend & re-bend tests	Pass	Pass	Testing in approved lab

The requirements are not limited to those mentioned above. For details of the requirements, refer to BS 4449

2.4.1.8 Acceptance Criteria and Permissible Limits for Coarse Aggregate

Coarse Aggregates - Physical Tests													
a. Determination of particles size	Sieve	Percentage passing for Single-Sized Aggregate of Nominal Size					Percentage Passing for Grades Aggregate of Nominal						
		40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm			
3	63 mm	1	-	-	-	-	-	-	-	-	-	-	-
	40 mm	85 - 100	1	-	-	-	95 - 100	1	-	-	-	-	-
	20 mm	0 - 20	85 - 100	100	-	-	30 - 70	95 - 100	1	-	1	-	-
	16 mm	-	-	85 -	1	-	-	-	-	90 - 100	-	-	-
	12.5 mm	-	-	-	85 - 100	1	-	-	-	-	90 - 100	-	-
	10 mm	0 - 5	0 - 20	0 - 30	0 - 45	85 - 100	10 - 35	25 - 35	30 - 70	40 - 85	-	-	-
	4.75 mm	-	0 - 5	0 - 5	0 - 10	0 - 20	0 -	0 - 10	0 - 10	0 - 10	0 - 10	-	-
	2.36 mm	-	-	-	-	0 - 5	-	-	-	-	-	-	-
b.	Flatness index	Not to exceed 25%											
c.	Crushing value	Not to exceed 45%											
d.	Presence of deleterious material	Total presence of deleterious materials not to exceed 5%											
e.	Soundness test (for concrete work subject to frost)	12% when tested with sodium sulphate and 18% when tested with magnesium sulphate											

2.4.1.9 Acceptance Criteria and Permissible Limits for Fine Aggregate






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		Percentage Passing for Graded Aggregate of Nominal Size			
4	Fine aggregates - Physical Tests	Sieve Designation	F.A. Type I	F.A. Type II	F.A. Type III
a)	Determination of particle size	10	1	1	1
		4.75	90 -	90 -	90 -
		2.36	60 -	75 -	85 -
		1.18	30 -	55 -	75 -
		600 microns	15 -	35 -	60 -
		300 microns	5 -	8 -	12 -
		150 microns	0 -	0 -	0 -
b)	Silt content		Not to exceed 8%	Not to exceed 8%	Not to exceed 8%








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c)	Presence of deleterious material	Total presence of deleterious materials shall not exceed 5%
d)	Soundness Applicable to concrete work subject to frost action	12% when tested with sodium sulphate and 15% when tested with magnesium sulphate

2.4.1.10 Acceptance Criteria and Permissible Limits for Concrete Work

1)	Concrete	a) Workability	Slump shall be recorded by slump cone method and it shall be between 50- 100 mm for pile cap and chimney, 150mm to 200mm for concrete pile.
		b) Compressive strength	One set for each pile. For Pile caps, beams, Chimney, one set for every 6 Cu.m. or part thereof for each day of concreting. Each set consists of four cubes, one for 7 days testing and two for 28 days testing shall be taken.

Notes - Acceptance Criteria are based on 28 days compressive strengths for nominal mix concrete:

- The average of the strength of three specimen be accepted as the compressive strength of the concrete, provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.
- If the actual average strength of accepted sample exceeds specified strength by more than 30%, the Engineer-in-charge, if he so desires, may further investigate the matter. However, if the strength of any individual cube exceeds more than 30% of the specified strength, it will be restricted to 30% only for computation of strength.
- If the actual average strength of accepted sample is equal to or higher than specified up to 30%, the strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.
- If the actual average strength of accepted sample is less than specified strength but not less than 70% of the specified strength, the concrete may be accepted at reduced rate at the discretion of Engineer-in-charge.
- If the actual average strength of accepted sample is less than 70% of specified strength, the Engineer-in-charge shall reject the defective portion of work represent by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall take at the risk and cost of Contractor. If, however, the Engineer-in-charge so desires, he may order additional tests to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the Contractor.

General Notes:

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1. This standard Field Quality Plan is not to limit the supervisory checks which are otherwise required to be carried out during execution of work as per drawings/Technical specifications etc.

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2. Contractor shall be responsible for implementing/documenting the quality plan. Documents shall be handed over by the Contractor to Employer after the completion of the work.
3. Project in charge means over all in charge of work. Line In charge means in charge of the line. Section in-charge means in charge of the section.
4. Acceptance criteria and permissible limits for tests are indicated in the report. However, for further details/tests Employer specification and relevant standards shall be referred.
6. Tests as mentioned in this Quality Plan shall generally be followed. However, Employer reserves the right to order additional tests wherever required necessary at the cost of the Contractor.

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2.4.1.11 Route Clearance

Where clearing is in the opinion of the Employer necessary, the following requirements shall be observed. Trees and tall scrub shall be cleared to a distance of 14 m for 132 kV on either side of the centerline of the route. Trees and bushes shall be cut down to a height of not more than 1.0 m above ground level. In addition, tall trees outside the cleared area, of such height that they could fall within 2 m of conductors, shall be trimmed by the Contractor. No tree may be felled without the express permission of the Employer/ Project Owner. **This is a Hold Point.**

Chopped trees and scrub shall be removed from a path 3.5 m wide and running as far as possible continuously along the route. The Contractor shall grub up tree stumps and roots from this track.

All trees, bushes, bamboo and any other vegetation which normally grows to a height of 2.5 m or more shall be treated by an approved non-toxic, non-residual agent to prevent further growth.

The Contractor shall clear a 3.5 m wide agreed construction access track from public roads, of all trees, stumps, scrub and vegetation to tower positions as required by the Employer.

All felled trees or tree trimmings shall remain the property of the landowner.

2.4.1.12. Access Roads

Access roads/routes shall be identified by the Contractor themselves as and where necessary, and shall be constructed by them at their own expense and necessary compensations for damages thereof shall also be paid by the Contractor. The EPC Contractor can either lease or rent or permanently buy from the landowners. However, the most of the land from Solar Plant project area to Matarbari grid substation has been acquired by BEZA. The Employer's representative shall assist the Contractor in his negotiations with the landowners or the government authority about such compensation or approval etc.

2.4.1.13. Route Alignment

The preliminary route alignment finalized by the Employer with GPS as follows. The route alignment shall be carried out by the EPC Contractor using topographical maps. The routing of the transmission line shall be most economical from the point of view of construction and maintenance. During the construction,

alternative route alignments can be identified & examined and the contractor can suggest to the Employer the optimal route alignment. Routing of transmission line through protected/reserved forest area has been avoided. The route has aligned in such a way that cutting of trees is minimum. The route has minimum crossings of major river, over- head EHV power line and communication lines. The number of angle points has been kept to minimum. The distance between the terminal points specified has been kept shortest

possible, consistent with the terrain that is encountered. There is some Marshy and low-lying areas, river beds and earth slip zones so that special action shall be taken during the foundations. It would be preferable to utilize level ground for the alignment during construction. Crossing of power lines has been minimized. Alignment will be kept at a minimum distance of 300 m from power lines to avoid induction problems on the lower voltage lines. Crossing of communication line shall be minimized and it shall be preferably at right angle. Proximity and parallelism with telecom lines shall be eliminated to avoid danger of induction to them. Areas subjected to flooding such as canals shall be avoided. All alignment should be easily accessible both in dry and rainy seasons to enable maintenance throughout the year. Certain areas such as quarry sites, tea, tobacco and saffron fields and rich plantations, gardens & nurseries which will present the Employer problems in acquisition of right of way and way leave clearance during construction and maintenance should be avoided. Angle points should be selected such that shifting of the point within 100m radius is possible at the time of construction of the line.

2.4.1.14. Minimum Clearance

The minimum clearances detailed below must be achieved during the construction of the transmission line.

Description of Clearance - Minimum Clearance crossing obstacle

Ground	(m)	7.0
Roads	(m)	8.0
Buildings, structures, walls or other objects on which a person can stand or against which he can lean a ladder (see note b)	(m)	5.0
Trees	(m)	3.5
Shrubs	(m)	3.0
Railways (measured from railway track)	(m)	9.0
River Crossing	(m)	23.0

Notes:

- a. Clearances are measured to the nearest projection of an object.
- b. These clearances also apply to earthed metal clad buildings.
- c. Clearances applicable to trees under the transmission line and to trees adjacent to the line.
- d. Clearances also applicable to trees falling, towards the line with conductors hanging in a vertical plane.
- e. The clearance shall be measured from the highest flood level.

Clearances where Transmission Lines Cross

Where a transmission line crosses above or below another transmission line, the following clearances shall be obtained. In still air, and with the phase conductor temperature of the lower transmission line at 5°C or 80°C for 132 kV line whilst the assumed phase conductor temperature of the higher transmission line is at its maximum operating temperature, the following minimum clearances between the lowest conductor (phase or earth) of the higher transmission line are applicable:

System voltage (see Note i)	132 kV
The highest conductor (phase or earth) of the lower transmission line (see Note ii)	4.6 m

Notes:

- i. The voltage specified is that for which transmission lines are ultimately designed to operate.
- ii. Clearances are determined by the ultimate voltage of either the upper or lower transmission line, whichever is the greater.
- iii. Clearances are determined by the ultimate voltage of the upper/lower transmission line.

In addition to the above at the point of crossing, the clearance in (a) shall be obtained assuming the conductors of the lower transmission may swing up to 45° from the vertical. The sags of the upper and lower transmission lines shall be those at the maximum operating temperature.

2.4.1.15. Foundation

Foundations shall be of the open cast type and / or cast in situ piles. Plain cement concrete/reinforced cement concrete footings shall be used for all normal tower types. All four footings of the tower and their extensions shall be similar for a particular location, except where soil conditions and or water table are different at different legs. The total depth of foundation below ground level shall generally be 3.0 meters. For hard rock type and also where specific site conditions / properties demand foundations of different depths (lower or higher), the same shall be adopted. Furthermore, for multi-circuit tower foundations, foundation depth shall be 3.5 meters; for river crossing open cast foundations, the foundation depth shall be more than 3.5 meters. Foundations for towers for different categories of soil conditions shall be selected from the approved types detailed below:

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Parameter	Soil Category					
	1	2	3	4		
Soil classification	Dense sand or very stiff hard clay	Medium sand or stiff clay	Loose sand or soft to medium clay	Very loose sand or very soft to soft clay		
SPT "N" blows 1. Average SPT of top 75% of length in case of pile foundation 2. Average SPT of top 5 meter soil from existing ground level	>20	10-20	5-10	<5		
Water level	At depth of foundation level plus width of foundation from EGL		At ground level			
Soil density	kN/m ³	16	8	7	7	
Backfill density	kN/m ³	16	8	7	7	
Concrete Density	kN/m ³	24	14	14	14	
Allowable bearing pressure under ultimate applied loading	kN/m ²	CLAY	250	150	75	25
		SAND	350	250	120	80
Lateral earth pressure (for shallow foundation)	kN/m ²	Rankine's theory of earth pressure is applicable				
Friction angle (degrees to vertical)		15	15	10	0	

Parameter	Soil Category 2,3 & 4	
For sandy soil Ultimate skin friction = $\frac{1}{2} K_s p_d \tan \delta A_s$		where p_d = effective overburden pressure ϕ = angle of shearing resistance A_s = surface area of pile shaft (m ²)
Bored piles K_s	0.7	
δ	ϕ	
Driven piles: Steel K_s	0.5	
δ	20°	
Concrete K_s	1.0	
δ	$\frac{1}{2} \phi$	
For clay soil Ultimate skin friction = $\alpha C_u A_s$	$\alpha = 0.7 - 0.3$	where α = attachment coefficient C_u = Undrained shear strength

Minimum Requirement for Piled Foundations:

Parameter	Requirement
Minimum factor of safety for piles or drilled shafts i.e. ultimate resistance to allowable load (for all types of soil categories)	2.0
Minimum percentage of ultimate uplift load (without foundation strength factor) to be resisted by dead weight of piles & pile cap (for soil category 4 only)	25%

All materials used in the production of concrete, including all admixtures shall be in accordance with the requirements of BS 8500 and BS EN 206. Cement shall be either:

- a. Portland cement in accordance with BS EN 197- 1 strength grade 42.5N;
- b. Sulphate resisting Portland cement in accordance with BS 4027 strength
- c. grade 42.5N LA;

- d. Portland cement combined with a minimum of 25% and a maximum of 40% of pfa. Complying with BS 3892 Part 1.

The maximum particle size of the aggregates shall be so chosen as to be compatible with mixing, handling, placing, and workability of the concrete.

All stub steelwork, pole sections and holding down bolts shall be protected by hotdipped galvanising to comply with the requirements of BS EN ISO 1461.

2.4.1.16. Towers

The scope of the project shall include the design, supply, installation, testing and commissioning of the 132 KV Transmission line towers.

Design Parameters

	132 kV
3 s gust wind speed (FL)	80 m/s
Wind load factor	1.15
Exposure category	C

Conductor System Loading

Loading Condition	Maximum Allowable Tension
Normal condition (Failure limit)	80% of Ultimate tensile strength
Normal condition (Damage limit)	50% of Ultimate tensile strength
Everyday condition	20% of Ultimate tensile strength

The ground earthing conductor shall be provided on all lattice towers standard heights adjacent to the stub connection, leg and body extension and cleats of stubs. The maximum value of the earthing resistance shall be 5 Ω.

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2.4.1.16. 1 Classes of Towers

The steel towers required in this project are 132 kV double or four circuit towers: three phase in vertical formation lattice steel towers with single Grosbeak (636 MCM ACSR) phase conductors and one or two earthwire, OPGW type with 24 fibres, mechanically equivalent with 59 mm² ACS earthwire.

2.4.1.16. 2 Designation & Uses of Towers

Designation	Angle of Deviation / Entry	Description	Type of Insulator Set
132 kV Double Circuit Tower			
1DL	0°	Intermediate	Suspension
1D3	0° - 3°	Angle	Heavy Suspension
1D25	10° - 25°	Angle/Section	Tension




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ID60	25° - 60°	Angle	Tension
IDT90	0° - 30°	Terminal	Tension
	60° - 90°	Angle	Tension

Note: IDT9: Auxiliary crossarms to be designed for down downloads only

Designation	Angle of Deviation / Entry	Description	Type of Insulator Set
132kV four circuit tower for single ACSR Grosbeak			
1QL	0°	Intermediate	Suspension
1Q15	0° - 15°	Angle	Heavy Suspension
1Q30	0° - 30°	Angle/Section	Tension
1QT6	30° - 60°	Angle	Tension
	0° - 30° (Angle of Entry)	Terminal	Tension

2.4.1.16.3 Materials

All steel shall comply with BS EN 10025 or BS EN 10210 as appropriate and shall be suitable for all the usual fabrication processes, including hot and cold working within the specified ranges. The quality of finished steel shall be in accordance with BSEN 10163. All steel shall be free from blisters, scale, laminations, segregation and other defects. There shall be no rolling laps at toes of angles or rolled-in mill scale. The following grades of steel shall be applicable:

- a. Mild steel shall be either grade S235JRG2 or S275JR.
- b. High tensile steel shall be grade S355JR

Steel section profiles shall be in accordance with the requirements of BS 4: Part 1, BSEN10210-2, BSEN 10056-1, BS EN 10024, BS EN 10034 and BS EN 10056-2 as appropriate. Hot rolled steel plate, 3 mm thick or more, shall be in accordance with the requirements of BS EN 10029.

Malleable cast iron shall be in accordance with the requirements of BS EN 1562 for white heart or pearlite and BSEN 1563 for spheroidal graphite.

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The following grades of steel shall be applicable for Bolts, Nuts, ClevisPins and Washers:

- a. Material quality of bolts of 12 mm diameter shall be Grade 4.6 according to ISO 898
- b. Material quality of bolts and clevispins of 16 mm diameter and over shall be Grade 5.6 according to ISO 898.
- c. Material quality of non-structural step bolts shall be Grade 6.9 according to ISO 898.
- d. Material quality of nuts shall be Grade 5 according to ISO 898 and appropriate to the material quality of bolts.

Bolts and nuts shall be ISO Metric Black Hexagon to BS 4190, and shall be threaded ISO metric course pitch to BS 3643: Part 2, tolerance class 7H/8g. Countersunk and other bolts without hexagon heads shall have slotted heads. All flat washers shall comply with the requirements of BS 4320, Form E, Grade 4.6 or 5.6 appropriate

to the material quality of bolts. Unless specified to the contrary they shall be 3 mm thick. Pack washers shall have an external diameter of twice the nominal bolt diameter +15 mm, a hole diameter of nominal diameter +2 mm and a thickness as specified on the appropriate fabrication drawing. Single core spring washers shall comply with the requirements of BS 4464, Type B. Split pins shall comply with the requirements of BS 1574 and shall be of austenitic stain- less steel capable of complying with the requirements relating to the inter-crystalline corrosion test of BSEN 10083 etc.

2.4.1.16. 4 Span Criteria

1.0 Climatic Loadings and Security Loadings (Intact Conditions)				
1.1 Suspension, Heavy Suspension & Tension Towers				
				132 kV
Basic Span (m)				300
(a)	Wind span (A)	Suspension Towers	(m)	330
		Heavy Suspension Towers	(m)	330
		Tension Towers	(m)	330
(b)	Maximum weight span	Suspension Towers	(m)	415
		Heavy Suspension Towers	(m)	415
		Tension Towers	(m)	415
(c)	Minimum weight span	Suspension Towers	(m)	110
		Heavy Suspension Towers	(m)	110
		Tension Towers	(m)	110
1.2 Terminal Towers				
(a)	Wind span (A)		(m)	260
(b)	Maximum weight span		(m)	310
(c)	Minimum weight span		(m)	zero
2.0 Security Loadings (Broken Wire Conditions)				
2.1 Suspension & Tension Support				
(a)	Wind span (A)	Suspension Towers	(m)	225
		Heavy Suspension Towers	(m)	225
		Tension Towers	(m)	225
		Suspension Towers	(m)	310

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(b)	Maximum weight span	Heavy Suspension Towers	(m)	310
		Tension Towers	(m)	310
(c)	Minimum weight span	Suspension Towers	(m)	110
		Heavy Suspension Towers	(m)	110
		Tension Towers	(m)	110

2.4.1.16.5 Minimum Thickness & Diameter of Material

The minimum thickness and diameter of material used in members and bolts shall be as detailed below:

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(a)	For leg members and compression chords in gantries and cross arms.	(mm)	6
(b)	For other members (including earthwire peaks) carrying calculated stress.	(mm)	5
(c)	For secondary members without calculated stress.	(mm)	4
(d)	Gusset plates for lattice towers.	(mm)	6
(e)	Bolt diameter for members carrying calculated stress.	(mm)	16, 24
(f)	Minimum bolt diameter for secondary members without calculated stress	(mm)	16

2.4.1.16. 6 Protective Treatment

After completion of all fabrication processes (including all drilling, punching, stamping, cutting bending and welding) support steelwork, poles and pole steelwork, including nuts, bolts and washers shall be hot-dip galvanized and tested in accordance with the requirements of BS EN ISO 1461. Electro-galvanizing is not an acceptable alternative.

The minimum average coating thickness shall be as follows:

	Thickness μm	(Mass g/m^2)
Steel articles which are not centrifuged, 5 mm thick and over	85	(610)
Steel articles which are not centrifuged, under 5 mm but not less than 2 mm	64	(460)
Grey and malleable iron castings	85	(610)
Threaded works and other articles which are centrifuged	43	(305)

The ingot zinc used for galvanizing shall comply with the requirements of BS EN 1179. All materials prior to galvanizing shall be free from oil, grease or any substance which may adversely affect the quality of finish. Castings should be as free as possible from surface porosity and shrinkage holes and should be cleaned by grit blasting, electrolytic pickling or by other means especially suitable for castings. The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated materials. All materials shall be treated with Sodium Dichromate in order to prevent wet storage stains (white rust) during storage and transport. All bolts and screwed rods, including the threaded portions, shall be galvanized. The threads shall be cleaned of all surpluses on packing, clear of the ground and away from all materials that might stain or corrode the galvanizing. Black steel packing or bins shall not be splintered by

spinning or brushing. Dies shall not be used for cleaning threads other than on nuts. Nuts shall be galvanized and tapped 0.4 mm oversize and threads shall be oiled. Bolts shall be delivered with nuts run up the full extent of the thread. All galvanized materials shall be stored used.

2.4.1.17 Insulators:

All insulator units shall be designed to withstand the design service voltages including lightning, switching and power frequency, the mechanical loads relevant to the installation - service - maintenance conditions,

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the service temperature and environmental effects. Internal stresses due to expansion and contraction of any part of the insulator unit shall not lead to deterioration.

The design of insulator units shall be such as to avoid local corona formation and no significant radio interferences shall be exhibited. Cap & pin insulator units shall comply with the general requirements of the IEC 60305 standard. The dimensions of all insulator units, together with materials and grades and other pertinent information shall be as per attached drawings. Particular regard shall be paid to those dimensions which involve interchangeability, correct assembly and those for which gauges are specified. Where appropriate insulator caps and pins shall comply with the requirement of IEC 60120, IEC 60372 and IEC 60471. Porcelain shall be sound, thoroughly vitrified and free from defects and blemishes which might adversely affect the life of the insulator units. All insulator caps and bases are to be free from flaws, blowholes and shall be of a close- grained quality. Insulator pins shall be round, free from cracks, surface flaws, lamination and other defects.

The selection and types of the insulators are as follows:

Insulator Set Type	Suspension / Heavy Suspension*	Tension	Low Duty Tension	Jumper Suspension
Nominal system voltage	132 kV			
String configuration	single	single	single	Single
Reference drawing				
Insulator unit type	Cap & pin type disc insulator			
Coupling type as per IEC 60305	Ball & socket			
Insulating material	Porcelain			
Security clip type	R			
Zinc sleeve	Required			
Head design	Straight head			

The detailed electrical and mechanical properties of the insulators are as follows:

Parameter	Suspension/ Jumper Suspension	Heavy	Tension	Upright Low Duty	Inverted Low Duty

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Pollution category		Medium II				
Nominal creepage	mm	2900				
Insulator type		Cap & pin type disc insulators				
Insulator unit reference		U70BL	U120B	U120B	U70BL	U70BL
Glaze colour		Brown	Grey	Grey	Brown	Brown
Unit puncture voltage	kV	110	110	110	110	110
Number of insulator units per string		10	10	11	11	11
Dielectric material		Porcelain				
Max. insulator string length without fittings	mm	10x146	10x146	10x170	11x146	11x146
Dry lightning impulse withstand voltage	kV	650				
Wet power frequency withstand voltage	kV	275				
Power arc for insulator set						

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• Current	kA	31,5				
• Duration	s	0.5				
Power arc for string insulator units: Current for duration	kA for s	12 for 0.1 or 6 for 0.2				
Arc gap nominal	mm	1120	1120	1120	1000	1000
RIV level per unit	δB	42				
RIV level per set	δB	30				
Mechanical/ electromechanical Failing load	kN	70	120	210	70	70

2.4.1.18 Insulator and Conductor Fittings:

All insulator and conductor fittings shall be designed so as to:

- a. avoid damaging the conductor under all service conditions;
- b. withstand the mechanical loads relevant to the installation-service-maintenance conditions, the design service current including short circuit effects, the service temperature and environmental effects;
- c. be free from visible and audible corona discharge and radio interference at the voltage levels
- d. specified, except those designed exclusively for use on earthwires;
- e. minimize the number of parts and the possibility of incorrect assembly and installation;
- f. ensure that individual components are secured against becoming loose in service, and all threaded fasteners shall be locked;
- g. Compression fittings after compression shall not permit relative movement between the individual layers of the conductor.
- h. from material, which have sufficient strength, ductility and environmental resistance to withstand the static and dynamic loading.

Where appropriate insulator and conductor fittings shall be in accordance with the requirements of IEC 61284. Ball and socket coupling shall be in accordance with the requirements of IEC 60120. Socket fitting shall be designed for 'W' type security clips or 'R' type security pins in accordance with the requirements of IEC 60372 as appropriate, clevis tongue couplings shall be in accordance with the requirements of IEC 60471.

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All factory formed helical fittings shall be performed with a right hand lay and shall completely enclose the conductor except for small gaps required to ensure that all rods make good contact with the conductor over their entire length.

The selection of insulator fittings with mechanical and electrical properties is as follows;

Insulator Fittings - Types & Uses - 132 kV



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		Heavy Suspension			Pilot Suspension
Reference drawing					
Set configuration	Single	Single	Single	Single	Single
No. of insulator strings	1	1	1	1	1
Min. separation between centres of parallel strings (mm)	-	-	-	-	-
Coupling type	Ball & Socket	Ball & Socket	Ball & Socket	Ball & Socket	Ball & Socket
Security clip type	R	R	R	R	R
No. of sub-conductor	1	1	1	1	1
Sub-conductor spacing (mm)			-	-	-
Live line working	Required	Required	Required	Not Required	Required
Sag adjuster type	-	-	Quadrant	Turnbuckle	-
Line arange (mm)	-	-	75 - 225	230	-
Increment (mm)	-	-	-	-	-
Overall set length (mm)	2000	2000	2400	2350 (A) 2900 (B)	1950
Min. failing load complete set					
• Common to all conductor (kN)	70	120	120	70	70
• Common to individual Conductor (kN)	70	120	120	70	70
Insulator protective devices: Type					
• Live end	Single Point	Single Point	Single Point	Single Point	Single Point
• Earth end	Single Point	Single Point	Single Point	Single Point	Single Point

(A) Upright (B) Inverted

2.4.1.19 Conductor and Earthwire:

The type and configuration of phase conductor and earthwire shall be in accordance with the requirement of following specification

Conductor	Phase	Earthwires
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Designation (Code Name)	Grosbeak	OPGW 7x3.25 GS equiv.	GS 7 x 4.0
Type	ACSR	"A"	"G.S."
Reference standards	ASTM B232	IEC 61089	IEC 61089
Aluminium Alloy Grade	-	as appropriate	-
Steel Grade	-		11,5
Galvanising Thickness	-	-	-
Aluminium class (AS wire)	Ref IEC 61232	-	-
Aluminium type (AS wire)	-	20 % IACS	
Conductor operating temperature range (°C)	5-80	-	-
Minimum mass of grease (kg/km)	-	-	-
Creep period of conductor to be considered (years)	20	-	20
Number and diameter of wire (no./mm)	A1. 26/3.973 St 7/3 089	-	7/4.0 GS
Overall diameter (mm)	25,16	-	12,34
Nominal breaking load (kN)	112	-	101,41

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Weight (kg/km)	-	-	-
Direction of external lay	Right hand	Right hand	Right hand

2.4.1.20. Vibration Dampers

Vibration dampers shall be either of the Stockbridge type comprising two weights attached via a messenger cable to a conductor clamp, or spiral type (SVD) for installation on the conductor, OPGW or all dielectric self-supporting (ADSS) optical fibre cable for which the damper is designed.

Vibration Dampers Types & Uses - 132 kV Line

Parameters	Conductor Type	
	Phase	OPGW
Conductor designation	636 Grosbeak	To match 7 x 3.25
Conductor material	ACSR	AS
Armour rods fitted	YES	YES
Basic span (m)	300	300
Everyday temperature (°C)	30	30
Everyday tension (kN)	22	Sag matched to 7 x 3.25
Vibration damper Type	Stockbridge	Stockbridge

2.4.1.21 Optical Fibre Cable and Fittings

The fibre optic earthwire to be supplied shall be suitable for installation on transmission lines, and shall be supplied complete with all necessary fittings and optical joint boxes. Optical fibres shall be single mode fibre. The fibres shall be coded for ready identification at each end. Single mode fibres shall conform to ITU-T G652 or to IEC 60793-2-B1.

Optical Joint Boxes:

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Optical joint boxes shall be provided to protect the splice joints of optical fibres, either when individual lengths of fibre optic OPGW, are jointed, or between the fibre optic earthwire and the underground fibre optic cable. The optical joint boxes shall protect the splice joint from both mechanical and environmental damage. The joint boxes shall consist of an external steel or die cast aluminium housing and provide protection to IEC 60529 IP447, and an internal die cast aluminium or high impact plastic ABS box to IEC 60529 IP54.

Fixing Clamps

A bolted clamping system shall be used to attach the OPGW to the inside of the support without drilling or modifications to the support steelwork. The clamping system shall be capable of use with galvanised steel angle sections varying between 40 and 200 mm wide and accommodating either single, double or multiple lengths of OPGW.

Non-Metallic Underground Fibre Optic Cable

The fibre optic cable shall be circular in cross section and shall be designed so that any cable strain is not directly imported on the optical fibres. The cables shall not include any metallic components, to prevent high induced voltages when used in switching or substation compounds.

OPGW Design Requirements - 132 kV

Parameters	Unit	132 kV
Number of fibres		24
Fault current (1 second)	(kA)	5
Initial temperature	(°C)	40
Leading edge	(µs)	1.2
Lightning initial peak current	(kA)	100
Tail	(µs)	50
Power follow through	(Coulomb)	200
Temperature cycling test T _A	(°C)	5
Temperature cycling test T _B	(°C)	40

Single Mode Optical Fibre Cable Requirements

Coating diameter		µm	250 ± 15
Cladding diameter		µm	125 ± 3
Cladding non-circularity		%	≤2
Mode field diameter		µm	9 ± 1
Mode field concentricity error		µm	≤1
Cutoff wave length		nm	≤1,270
Attenuation at (maximum average)	1285 nm 1330	dB/km	≤0.40
Attenuation at (maximum average)	1550 nm	dB/km	≤0.25
Zero dispersion wavelength		nm	≤1,321
Chromatic dispersion at	1285 nm 1330	ps/(km-nm)	≤3.50
Chromatic dispersion at	1550 nm	ps/(km-nm)	≤20
Individual splice loss		dB	≤0.10
Mean splice loss		dB	≤0.06

2.4.1.22 Switchgear for Bay Extension

The switchgear shall be suitable for outdoor location and capable of continuous operation under the climatic conditions existing onsite. It shall be designed to comply with the Specification and relevant IEC and British Standards where applicable. Insulation creepage distances shall not be less than 25mm per kV rated voltage between phases.

2.4.1.22.1 circuit Breaker

Circuit breakers shall be of the outdoor SF6 gas type with spring-stored energy operating mechanism. Proposed 145kV circuit breakers, with spring-stored Energy Operating Mechanism. The rated current of the circuit breakers shall be 1250A and the short circuit breaking current 40KA rms, 3s.

2.4.1.22.2 Disconnecter & Earthing Switches:

Disconnecting and earthing devices shall be in accordance with IEC 62271-102 and IEC 60265-2. Transformer disconnectors in transformer circuits without circuit breakers on the High Voltage side shall be in accordance with IEC 60265-1 and shall be capable of breaking the transformer magnetising current. All shall be complete with supporting steelwork and installed to permit maintenance of any section of the substation plant when the remainder is alive and shall be so located that the minimum safety clearances stated in BS 7354 are always maintained. In outdoor substations, disconnectors shall be of the single throw double air break, centre rotating post type or of the single air break double rotating post or vertical break type. Disconnectors shall comply with the requirements of BS 5253 Clause 37.6 in respect of lightning impulse voltage tests.

2.4.1.22.3 Voltage Transformers

Voltage transformers shall comply with IEC 60044-2 & 60044-5 and the requirements of this specification. Those for the 132 kV system shall be of the capacitor type with a total greater than 6,000 pF each.

2.4.1.22.4 Current Transformers

Current transformers shall comply with IEC 60044-1 and the requirements of this Specification. Primary winding conductors shall be not less than 100sq.mm section and shall have a one second short time current rating not less than that of the associated switchgear. Secondary windings of each current transformer shall be earthed at one point only.

2.4.1.22.5 Protection, Control and Metering:

The protection shall be sufficiently sensitive to cater for the minimum fault level condition. The protection shall also be suitable for a system fault level equal to the switchgear rating of 31.5kA for 33kV and 40KA for 132kV system. All current transformer design shall be based on these fault levels. All relays shall operate correctly within system frequency limits of 47Hz to 51Hz.

The following protection scheme shall be ensured:

1. Over Current and Earth fault protection
2. Bus bar protection (Double bus scheme)
3. CIRCUIT BREAKER FAILURE PROTECTION
4. Auto Reclosing Protection
5. Coupling Bay Protection

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2.4.1.23. Bill of Materials for 04 Nos Bay Extension at 132KV Substation in Matarbari & Chokoria:

Bill of Materials for 132KV Bay Extension			
	Description of Item	Unit	Quantity
1	Circuit Breaker 145 kV, 1250A, 40kA, 50Hz, 650/275 kV BIL, live tank type, SF ₆ gas, with three spring-stored energy operating mechanism	Set	4
2	Disconnecter with Earthing Switch 145kV, 1250A, 40kA, 50Hz, 650/275 kV BIL, three pole, centre break, post type, motor operated disconnector with motor-operated earthing switch	Set	4
3	Disconnecter 145kV, 1250A, 40kA, 50Hz, 650/275 kV BIL, three pole, centre break, post type, motor operated	Set	8
4	Current transformer 145kV, 40kA, 50Hz, 650/275 kV BIL, single phase, 1200-600/1/1/1/1 A/A, 5-core, multi ratio, post type	Set (1 set =3Nos)	4
5	Voltage transformer 145kV, 50Hz, 650/275 kV BIL, single phase, 132/V3 / 110/V3 / 110/V3 kV/V/V, 2 secondary windings, capacitor type	Set (1 set =3Nos)	4
6	Surge arrester 145kV, 120 kV continuous operating voltage, 10kA nominal discharge current, 50Hz, single phase, heavy duty, station class, gapless, metal oxide type	Set (1 set =3Nos)	4
7	Protection Control and Metering Panel	Set	4
8	Conductors for busbar system and for connection of the 132 kV switchgear	Lot	1
9	Insulators and fittings incl. all necessary clamps and connectors required for completing 132 kV switchgear	Lot	1
10	Gantry steel structures and equipment supports required for completing 132 kV switchgear	Lot	1
11	All other necessary material and equipment required for completing 132 kV switchgear.	Lot	1

2.4.2 Civil and Mechanical Requirements

2.4.2.1 General

The following requirements shall be taken into consideration by the Contractor.

- For all permanent structures and if required by local authorization also for temporary structures, buildings, foundations, base plates and similar a verifiable structural verification according to Standards and Regulations by an expert shall be provided. The final design shall be clearly documented in detailed drawings.
- For the complete structure and structural components, buildings, basins, base plates and foundations, deep foundations and pilings the design method "Load and Resistance Factor Design" (LRFD) shall be used.

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- All engineering details must be supplied for approval prior to beginning any construction. For this, a procedure shall be implemented together with the Employer during the design and construction phase.
- Wherever stairs or staircases should be required, the design has to respect a secure ratio between height of stair section and tread length. The height of stair section shall be uniform from the first until the last riser of a flight of stairs or between the top of the lower finished floor level to the top of the upper finished floor level. The correctness of this matter will be subject of approval by the Employer on site after construction. Together with the width of the staircases or all other relevant parts of the buildings or structures such as the railings and their maximum clear width between rails, mid rails, posts, the requirements given in the BNBC and Chinese Standards and Codes shall be followed.
- If the mounting structures shall be founded by short pile foundations (pre-drilled and concreted or rammed) local pile tests on the site shall be carried out in a professional manner and sufficient number besides the structural analysis of the foundations.
- Based on the preliminary soil specification it is expected that all permanent structures (buildings, bridges, base plates, etc.) will be founded by pile foundations. The design of these foundations shall be done in close coordination with the geotechnical expert.
- For preliminary information a soil investigation report is enclosed. Besides, the Contractor shall have soil investigations performed at his own expense and have gathered all necessary information for this project in sufficient detail to ensure that all foundations are most suitable and safe and are properly designed with regard to soil conditions of the total PV Plant site. The geotechnical report shall consider the different types of structures and loads on site, same as the local site conditions (backfilling works, achievable compaction, site level and level of surroundings, etc.).
- All construction activities shall occur within the boundary limits with the exception of those activities related to the interconnections between the site and the common infrastructures, which will be performed by the Contractor outside the Plant boundary, such as electrical interconnection to the PV Substation, construction power supply, telecommunications and access road interconnection.
- During the subsequent execution of this project, the contractor can optimize and adjust the preliminary plan based on the actual on-site conditions, while meeting the technical requirements specified in this document and ensuring project safety, and it shall be confirmed by the employer.

The Contractor shall develop and implement its own Storm Water Pollution Prevention Plan (SWPPP) in order to manage storm water and control erosion. The objectives of the SWPPP are as follow:

- Control of erosion, and discharge of sediment
 - ◇ Minimize disturbed areas: Contractor shall only clear land that will be actively under Construction in the near-term. He shall minimize disturbance of new land during the rainy season, and avoid clearing and disturbing sensitive areas and other areas where site improvements will not be constructed.
 - ◇ Stabilize disturbed areas: Contractor shall provide temporary stabilization of disturbed soils whenever active construction is not occurring on a portion of the Site and provide permanent stabilization during the final grading and landscaping of the Site.
 - ◇ Protect slopes and channels: Contractor shall safely convey runoff from the top of the slope and stabilize disturbed slopes as quickly as possible. It shall avoid disturbing natural channels, stabilize temporary and permanent channel crossings as quickly as possible and ensure that increases in runoff velocity caused by the Project do not erode the channel.
 - ◇ Control site perimeter: Contractor shall delineate the site perimeter to avoid disturbing areas outside the PV Plant limits. It shall divert upstream runoff safely around or through the site. Local codes usually state that such diversions must not cause down stream property damage, or be diverted into another watershed. Runoff from the site should be free of excessive sediment and other

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constituents. Contractor shall also put in place control tracking at points of ingress to and egress from the site; and

◇ Retain sediment: Contractor shall retain sediment-loaded waters from disturbed, active areas within the site.

➤ Manage Non-Storm water Discharges and Materials:

◇ Practice good housekeeping: the Contractor shall perform activities in a manner to keep potential pollutants from coming into contact with storm water or being transported off site to eliminate or avoid exposure; and

◇ Contain materials and wastes: the Contractor shall store construction, building and waste materials in designated areas, protected from rainfall and contact with storm water run off. He shall dispose of all construction waste in designated areas, and keep storm water from flowing onto or off of these areas. The Contractor shall also prevent spills and make spilled materials cleaned up.

➤ The structure shall have to comply with the following minimum requirements:

◇ The structure shall be suitable for the operation of robot for cleaning purpose.

◇ At no time, including flood and storm conditions, any electronic equipment shall be submerged under water;

◇ As a precautionary measure, in case the drainage system would not be able to impede flooding inside the Project’s perimeter under some extreme circumstance, the supporting structure must ensure that the PV modules stand at a minimum height of 3.8 m above the terrain; the Contractor will be fully responsible for the calculation of this height in a way that ensures compliance with requirement (b) of this list;

◇ At all times, it shall be possible to properly access all equipment and System for maintenance purposes;

◇ The materials shall be designed for marine-type environment;

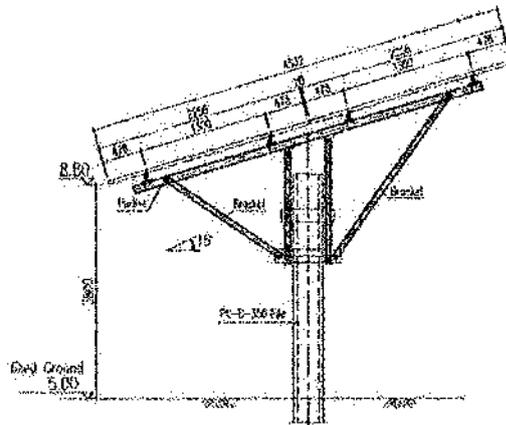


Figure 5.4.2: Bracket Structure

2.4.2.2 Loads and Loading Conditions of Structures and Buildings

All structures and buildings shall be designed in a professional way and follow all the requirements of safety, stability and usability. The Bangladesh National Building Code (BNBC) and Chinese standards shall be considered for the design of the Plant.

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The main load cases for structures, buildings and foundations design are as followed:

- dead load of structure
- dead load of equipment and components
- live loads including vehicle loads
- exceptional loads
- wind load (pressure and suction)
- temperature loads
- seismic load
- loads due to misalignment, settlement and similar.

Dead load, live load, wind or seismic load, temperature load and any other load case significant for the safe design of the structures shall be chosen according to structure and user specifications and engineering knowledge.

Roads, Bridges and any other structure and building stressed by vehicle traffic shall be designed in accordance with construction plan and fuel transportation study.

The loading conditions and load combinations defined in the BNBC shall be considered as minimum loads. The design situations shall be investigated in close coordination with Plant operation and long-life stability.

Designs with respect to engineering methods and knowledge can be accepted for small and minor buildings and structures. The same applies for small basins and ducts if no traffic loads occur.

Architecture, detailed construction and selection of building materials shall follow general and standard rules and structure design, also including but not limited to claddings, sleeves, embedded parts, anchor plates and openings.

Based on the site specifications, soft soil, high water level, high wind load, seismic load etc., the structural design for structures and foundations has to be done in a careful way to guarantee the Plant operation also under extreme conditions.

PV structures are generally constructed as lightweight structures and are therefore sensitive to wind loads. The main wind load has to be applied for a wind direction that is perpendicular to the PV modules. The load distribution over the depth of the structure shall be like for mono slope free roofs for pressure and suction. The load shape application is defined in the Building Code, load case A and B shall be considered.

Wind shadow effects for row-to-row structures have to be justified by appropriate tests or wind channel analysis or scientific studies of comparable structures and arrangements. The same applies if other (smaller) than required force and pressure factors shall be considered for the design. The professional documentation and evaluation of these studies and tests shall be implemented in the documentation.

All required bridges over existing natural drainage channels or new channels shall be designed for a minimum for truck load as required and coordinated with the Employer.

Due to the high water level, all base plates of buildings shall be designed according waterproof requirements. Uplifting due to a high water level shall be checked for all buried structures and foundations.

2.4.2.3 Design Method for Structural Verification

For the complete structure and structural components, buildings, basins, base plates and foundations the design method "Load and Resistance Factor Design (LRFD)" shall be used.

According to this concept the weighted resistances of the components concerned is checked against the ultimate (factored) actions applied to the structures:

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$$Ed \leq Rd$$

$$Ed \rightarrow \sum (\gamma_F \cdot F_k) \leq Rd = R_k / \gamma_M$$

where

Ed is the Effect to the structure, e.g. stresses due to loads multiplied by safety factors

Rd is the Resistance of structure, material, soil or similar element divided by safety factors

γ_F is the safety factor for Effects (variable acc. Standard for different load superposition and type of actions same as duration of action)

γ_M is the safety factor for Resistances (variable acc. Standard for different materials, actions and duration of action)

The directly calculated physical loads are increased by partial safety factors whereas the resistances are divided by material factors in order to consider uncertainties.

Partial safety factors for loads and material factors for building materials, soil, etc. shall be chosen according to Standards and Regulations. All required design situations and load combinations shall be determined and analyzed sufficiently.

2.4.2.4 Temporary Site Installations

All temporary site installations shall be located either within the PV Plant site (e.g. PV Plant lay-down area) or in off-site areas to be arranged by the Contractor. For the avoidance of doubts the Employer shall not be responsible for the provision of land for such off-site areas, however, the employer shall coordinate the Contractor to lease or get the temporary camp site. The temporary installations include labor camps, offices and car parking for the Employer's Representative and for the Contractor and his sub-contractors, workshop facilities, lay-down areas, etc. The Contractor is requested to review the local requirements, which might include restrictions for location of areas for labor camps.

The contractor shall consider 5 owner's representative and engineer offices of 126sqm. The area of Employer's representative's office shall be at least 30sqm. The area of Employer / Engineer's office shall be at least 24sqm for two people.

All the temporary building part of the camp shall be supplied with electric power, potable water, telephone lines, internet access and air conditioning and shall be connected to temporary sanitary water treatment units and earthing system as required by applicable Laws. The temporary offices for Employer's Representative and Engineer shall be provided complete with utilities connections, communication equipment and furniture (desks, chairs, lockers, etc.) At the appropriate time the Contractor shall extend the space of these offices for a convenient accommodation of the operational personnel to be trained on site, as required in par. 2.4.7 below.

Such offices shall be organized to ensure suitable spaces to carry out the training courses and shall be complete of any facilities and appliances required for an efficient execution of the courses.

Site installations and camps shall respect the demands of health and safety and environmental protection. If required, the Contractor shall provide a concrete platform for properly storing machinery and avoid oil spillage.

On completion of the construction phase, all temporary installations must be removed and demobilized leaving the occupied location clean and clear of debris or pollution.

2.4.2.5 Land filling



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Contractor shall only use suitable material for the intended use of the filled areas. The material shall be compacted as per structural analysis demands. The soil investigation report shall be kept up to date with the design and construction process. The soil investigation shall then be respected for the design and construction works. Furthermore, the demands of the highest flood levels and tidal effects shall be fully respected.

Land filling is required for the plant area. Contractor is responsible to calculate the earth requirement to filled the land. Measures such as clay soil filling on the top of layer and planting grass should be taken to protect the sand loss caused by wave or rain erosion on the site surface after sand blowing finished. The calculation shall take into consideration the following:

- Evaluation of availability of required landfilling materials in respect to defined standards and quality including rough estimation of transportation effort (capacity, time)
- Method statement for backfilling works, including specification for materials, special techniques and materials (like geotextile membrane or similar)
- Geotechnical specification of landfilled area estimation of load bearing capacities for foundations and piles
- notes for construction of roads and ways in these area,
- notes for drainage requirements, estimation of settlements expected
- notes for embankment protection
- In order to reduce the post construction settlement of the filled soil foundation, shorten the construction period of the filled soil foundation, and improve the stability of the site, plastic drainage boards should be considered for the treatment of the original soft soil to accelerate the drainage and consolidation of the soft soil, and ensure that the consolidation ratio of the soft soil before delivery is not less than 0.85
- After finish the treatment, the characteristic value of bearing capacity of filled soil for PV area: not less than 80kPa for non road areas, and not less than 120 kPa for road areas
- The area of the substation area shall not be less than 100 kPa.
- The Solar Power Plant site will be filled to 5m (MSL.) by land filling

2.4.2.6 Erosion Protection

When the adjacent water slope exists in the PV power plant site or the PV site is affect by the flooding water , the Contractor shall consider some erosion protection or anti-wave protection measures to protect the slope or site according to the hydrology wave study report of the project at the execution stage.

2.4.2.7 General Leveling and Grading

- Any debris, surplus or unsuitable material shall be removed from the site. Soft or unstable subsoil areas shall be excavated down to firm subsoil and shall be replaced with well compacted suitable transported fill material. In general, the leveling, compaction and grading of the entire site shall be with mild slopes and falls to provide free drainage.
- Leveling and grading of the site shall match the existing surrounding ground levels to facilitate free drainage of the site. Additional fill material required to achieve the falls necessary for free draining shall be suitable transported fill material. The finished site shall be well compacted to acceptable standards and grades. If necessary, a soil transportation (import/export) shall be executed;
- Finished ground floor level of technical and non-technical buildings shall be fixed mm at a sufficient height of at least 300 mm higher than the highest ground level if not otherwise required in



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order to ensure free drainage of the surrounding grounds away from the buildings also in times of heavy rain; and

- The minimum required land and road level of the PV Plant area shall be filled to 5.0m, and the expected events of flooding must be considered in the PV structure design and electrical cabling specification and detailed design.
- The elevation of substation and Gas Turbine area area is 9m (MSL).

2.4.2.8 Piling and Foundation

The works for foundations, deep foundations and piling shall be effected as per the PV Plants demand and shall strictly follow the soil investigation report.

Together with the demands of the structural analysis, the Contractor shall submit the foundation concept of each structure and building for approval by the Employer including pile load tests(horizontal and uplift)

The height foundation for prefabricated MV station shall meet the requirements of the highest flood level elevation in site, and the influence of settlement on equipment shall be considered. If necessary, Pile foundation shall be adopted.

2.4.2.9 Infrastructure and Outdoor Works

The following infrastructure and outdoor works are to be provided by the Contractor:

- Construction of new roads including access road from the approach road as indicated in Annex A-01 PV Plant Layout.
- Construction of parking areas and civil works as a part of the required infrastructure facilities and lighting system.
- Modification, improvement and upgrading of the existing infrastructure as required to adequately servicing the requirements of the PV Plant including repair and improvement of existing roads and ways to guarantee optimal access for construction, erection and transport of equipment to the PV Plant.
- Civil works for all required buildings, basins, foundations and base plates, retention areas, ducts, culverts, cable trenches, pipe trenches, cable bridges and ducts, conduits, inspection pits or inspection chambers, cable pulling pits, fencing, perimeter lighting, surveillance, I&C system and any other required structure including their corresponding foundations and infrastructure connection.

Civil works for equipment in outdoor inverter transformer stations, including their corresponding foundations and concrete platforms or basins:

- Construction of ducts, culverts, underground cable ducts, trenches, manholes, e.g. for MV and LV system cables, perimeter lighting, surveillance, I&C system, etc.
- Constructions, concrete covers, steel covers and the like shall be designed to withstand the load these members will have to face during operation of the plant, for example covers of inspection pits which are located in a road.
- Civil works for earthing and lightning protection system. Storm water drainage as necessary.
- Civil works for discharging rainwater, surface water and treated waste water including needed trench.
- Sanitary works as necessary including necessary piping, pumping stations and maintenance facilities.
- Safety and firefighting works as necessary.



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- Drainage and storm water collection system including additional facilities such as but not limited to retention basins. Separators, as required.
- Other civil works required inside the various corridors of the PV Plant.
- Any works that shall be affected in the area of the dam and in slopes have to be coordinated with the Employer first and shall be approved by civil engineering analyses and geotechnical experts.

2.4.2.10 Roads, Loading Capacities and Clearances

The Contractor shall take into consideration the loading capacities and clearances of existing bridges and connecting roads when carrying out transportation from the ports or from other places to the site and vice-versa.

Accesses road, overhaul roads, substation road and parking areas on the site of the PV Plant shall be designed and constructed of sufficient width and for maximum likely number of vehicles and loads for construction, operation and maintenance of the PV plant.

All necessary transports for operation and during construction process and general expected vehicle traffic shall be planned and considered sufficiently in design and construction. Layout, materials and construction specifications like layer material, thickness and compaction works as well as width, slope and curve radius according to vehicle sizes shall be defined in accordance with technical specifications and standards.

For roads and bridges minimum load model according GB codes shall be considered.

The detailed design of the roads and ways shall be planned to minimize O&M costs over the expected lifetime and to guarantee good and safe use.

One RCC + Asphalt road of at least 6.0m width shall be provided to connect the PV plant substation with the nearest or most favorable existing and asphalted road. Possible crossing points with railroads or bridges are to be considered.

The road within the new built substation should be at least 4.5m width. The road surface shall be finished by concrete paving or equivalent. Road layout shall generally permit vehicles to turn easily to avoid having to reverse out Road layout shall be designed by the Contractor.

The overhaul road widths and corresponding curves and slopes on the PV Plant shall be chosen in accordance to the plant operation concept. The maintenance road shall consist of at least 4m width and as per detail design (including sideways for cable channels if required and passing places in adequate number). In general for all roads on the premises gravel roads are preferred. In areas of high slope and along bridges asphalted roads are preferred to avoid potholes and ruts.

Internal roads shall be designed of sufficient, load capacity, curves and slope, gravel herringboned roads preferably following natural terrain surface.

In the design the Contractor will have to define a safety distance between the road shoulder and the PV modules and a respective curve radius in order to avoid damage or loss of the PV installations.

The natural terrain and backfilled areas shall be adequately prepared and sufficient stability shall be provided by plate load tests in sufficient number. All compaction works in areas of roads and pavement shall be done according to technical and environmental requirements. To stabilize the base course and avoid mixing of aggregate and natural terrain geotextile membrane shall be used as first layer for all types of roads and ways.

Along the roads infrastructure corridors shall be planned for electrical cables, pipes and any other required medium.

Crossings and embedment of cable channels and ducts have to be planned in coordination with electrical and O&M requirements.

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Necessary walkways and paved areas for required maintenance works same as comfortable access to buildings, equipment and installations shall be designed sufficient as preferably graveled paths and ways, in several cases regarding operational and maintenance requirements in asphalted quality.

2.4.2.11 water intake system

A water intake system for the PV Plant will be the Contractor's responsibility. The contractor shall provide the suitable water intake option according to Hydrology Report, Hydrogeology Report and the site condition, which shall be the

2.4.2.12 Site Drainage System

The drainage scheme shall be designed considering the Plant plot area and the catchment area contributing to the Plant area drainage. The rain water drainage system shall be a network of open surface drainage trench (with rectangular or trapezoidal cross section) and shall generally be designed to follow the natural flow of water and ground contours.

The contractor shall provide the suitable drainage system according to Hydrology Report and the site condition.

2.4.2.13 Waste Water Systems

a. Sanitary sewage system Sanitary sewage from the toilet, etc. shall be collected and discharged to sanitary sewage treatment system. And the treated water shall be reused.

b. Rainwater drainage system

The Contractor shall design and construct rainwater drainage network for smooth disposal of rainwater from the Plant to the nearest available drainage outlet. The rainwater drainage system shall be designed and planned to ensure no water stagnation in the Plant. Necessary input data for maximum hourly rainfall intensity to be taken for drainage design shall be obtained by the Contractor from Bangladesh Meteorological department.

c. Oil emergency discharge system

Oil pit is required under each oil transformer in the substation. Oil shall be diverted from oil pit into emergency oil discharge tank with enough capacity for the full amount of oil.

Oil and storm water pump-down from container shall be done by a tanker-vehicle with subsequent removal to the places specified by the appropriate authority.

2.4.2.14 Potable Water and Washing Water Systems Water Supply and storage tanks are under the responsibility of the Contractor. Water must be sourced and treated to allow human consumption and other uses in the Facility. The Contractor will furnish a water treatment plant (if necessary) with capacity to produce enough water to cover all the Facility’s consumption.

The following systems of water supply shall be provided in the Plant:

a. Drinking water supply providing water to meet the needs of the buildings and facilities on the site

b. Firefighting water supply

2.4.2.15 Fire Fighting and Detection System

The source of firefighting water supply system for the site shall be fire water tanks with the needed capacity which shall contain adequate water supply for firefighting.

The solar PV plant shall be equipped with suitable fire protection and fire fighting systems as per the National Fire Protection Association (NFPA) fire safety standard and local fire authority requirements.



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Fire-fighting for transformers and other electrical equipment shall be in accordance to NFPA 850 and NFPA 15.

2.4.2.16 Office Building

The design of the building and assumed loadings shall use the GB standards and also meet the related requirement of BNBC. Access and parking for the associated personnel shall be provided.

The office building is two storey building, the construction area of which is about 640m².

The office building with hall,meeting room,office room,ktchen, dinning room,archives,laundry room and rest room ,toilet,etc.

- ◇ Enclosure material:autoclaved aerated concrete block or concrete perforated brick is used for the area above ± 0.000 ,and concrete solid brick is used below ± 0.000 .
- ◇ Exterior wall:paint(or face brick).
- ◇ Interior wall:ceramic tile veneer is used in bathroom,and acrylic paint is used in other rooms.
- ◇ Ceiling:the ceiling adopt paint, and the ceiling is square aluminium panels where.
- ◇ Floor: the floor adopt vitrified tile floor.
- ◇ Doors and windows: the doors are steel door or wooden door.The windows shall be aluminum alloy windows with steel screen inside.
- ◇ Roof:waterproof grade II,the waterproof layer is made of polymer waterproof material;the thermal insulation layer is made of extruded polystyrene insulation board.
- ◇ The cover of the rain gutter shall be foreseen with hot-dip galvanized grating to avoid accidents.
- ◇ Openable windows shall be foreseen,which are intended to be closed when the air condition is running.
- ◇ The demands of fire protection and fire fighting have to be satisfied.Equipment for detection,protection and fighting of fire has to be foreseen and kept under maintenance.

2.4.2.17 Electrical Building

The design of the building and assumed loads shall use GB standards and also meet the related requirement of BNBC.

The electrical building is single storey building, the construction area of which is about 420m².

The electrical building with secondary equipment room and 33kv switchgear room.

- ◇ Enclosure material:autoclaved aerated concrete block or concrete perforated brick is used for the area above ± 0.000 ,and concrete solid brick is used below ± 0.000 .
- ◇ Exterior wall:paint(or face brick).
- ◇ Interior wall: paint.
- ◇ Ceiling: paint.
- ◇ Floor: the floor adopt vitrified tile floor.
- ◇ Doors and windows: steel fire door; aluminum alloy windows with steel screen inside.

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◇ Roof: waterproof grade II, the waterproof layer is made of polymer waterproof material; the thermal insulation layer is made of extruded polystyrene insulation board.

◇ The demands of fire protection and fire fighting have to be satisfied. Equipment for detection, protection and fighting of fire has to be foreseen and kept under maintenance.

2.4.2.18 Fire Pump House

The design of the building and assumed loads shall use GB standards and also meet the related requirement of BNBC.

The fire pump house is a single-story building.

◇ Enclosure material: autoclaved aerated concrete block or concrete perforated brick is used for the area above ± 0.000 , and concrete solid brick is used below ± 0.000 .

◇ Exterior wall: paint (or face brick).

◇ Interior wall: paint.

◇ Ceiling: paint.

◇ Floor: Wear-resistant concrete surfaces.

◇ Doors and windows: steel door; aluminum alloy windows.

◇ Roof: waterproof grade II, waterproof layer using polymer waterproof coil.

2.4.2.19 Security Fences and Security Gate

The PV Plant shall be enclosed by a security fence (chain linked fence) and a security wall of minimum requirements as stated below.

The security fence shall be steel mesh fence with a height of not less than 1.8 meters.

The fence shall meet the following functions:

- to fulfill all requirements of a security fence
- suitable for installing a lighting and monitoring system to provide sufficient illumination for the boundary area and camera surveillance of the site; and
- shall be designed according to national construction and environmental regulations
- shall prevent apes and monkeys to intrude the premises
- shall be constructed with a distance to the outer roads including a drainage ditch between the fence and the perimeter road.
- shall be integrated in the site drainage system, effective ways of discharge and overflow shall be foreseen.

The gate shall be designed as a hinged gate and made of mesh wire in similar design to the fence structure. The gate may be opened manually.

Behind the gate a barrier system shall be installed, which can be opened manually by the guard.

A check point for access control according to Employers.

The security fence shall be provided of a minimum of 1.8m height.

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Boundary wall shall be provided along the new built 132kV substation. The substation boundary wall shall be 2.3m high masonry wall with reinforced concrete framing. The substation gate shall be 1.8m high electric retractable gate. The gate shall be operable from guardhouse and the main control room.

The transformer site should be equipped with a 1.5m high safety fence

2.4.2.20 Operation and Maintenance Vehicles

Not used.

2.4.2.21 Degrees of Protection Against Access

Components such as transformer enclosures, inverter enclosures, cabinets, connectors, etc., shall be properly selected in order to guarantee the protection against ingress of solid and/or liquid harmful elements. Environmental site conditions should be taken into consideration during their selection.

It should be possible to open or enter the described equipment above only with a tool or a key to avoid access of unauthorized persons.

2.4.2.22 Technical and Non-Technical Buildings and Structures

All buildings and structures for the PV Plant and related equipment included the respective basins or enclosures shall form an integrated theme of high standard. They shall be designed to acceptable international standards and shall be fit for the purpose in each case. The works shall include but not be limited to excavations, foundations, reinforced concrete, masonry and structural steel, non-structural steel, waterproofing, oil-proofing, roofing, coating, rendering, painting, doors, windows, ironmongery as necessary. Power and lighting, earthing, lightning protection etc. Shall all be provided to acceptable high standards and workmanship.

2.4.2.23 Heating Ventilation and Air Conditioning (HVAC) Systems

➤ Design Standard and Code:

- ◇ 《Design code for heating ventilation and air conditioning of industrial buildings》 (GB50019-2015)
- ◇ 《Code for design of heating, ventilation and air conditioning of power plant》 (DL/T5035-2016)
- ◇ 《Code of acceptance for construction quality of ventilation and air conditioning works》 (GB50243-2016)
- ◇ 《Code for design of photovoltaic power station》 (GB50797-2012)

➤ Outdoor design parameters

The following outdoor meteorological parameters of Dhaka Hazrat Shahjalal INTL which quoted from ASHRAE HANDBOOK 2017(latitude is 23.843N, and longitude is 90.398E) would be adopted:

- ◇ Outdoor design temperature for ventilation (1% Evaporation MCDB/WB): 30.9/28.2 °C
- ◇ Outdoor design temperature for air conditioning (0.4% Cooling DB/MCWB): 33.2/26.9 °C
- ◇ Outdoor design temperature for heating (99% heating DB): 15.2 °C

According to the climate condition, the heating system will not be provided and the cooling system will be provided for the electrical equipment room.

➤ Indoor design condition



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No.	Room	Indoor dry-bull temperature (°C)
1	Control Room	24~28
2	Distribution Room	≤35
3	Battery Room	≤30
4	Electrical Relay Room	26~28
5	Office	26~28
6	Meeting Room	26~28
9	Dormitory	26~28
10	Pump House	≤40

➤ Air Conditioning and Ventilation System for Administration Building

The air-cooled air-condition system will be Control Room, Electrical Relay Room, Office, Meeting Room, Reception Room, Canteen and Rest Room.

In order to change the air after fire extinguishment, the mechanical exhausting system will be adopted in Electrical Relay Room. Mechanical ventilating system (natural air intake & mechanical air exhaust) is designed for the kitchen and toilet. The axial fan and ceiling type tubular fan will be provided.

➤ Cooling System for Electrical Building

To meet the indoor requirement, the air-cooled industrial air-condition system and exhaust system after fire extinguished will be designed for Distribution Room.

Cooling system and emergency ventilation system will be provided for Battery Room. Both air conditioner and exhaust fan would be anti-corrosion and anti-explosion type.

➤ Ventilation System for Pump House

Mechanical ventilating system (natural air intake & mechanical air exhaust) is designed for Pump House. The indoor temperature will not higher than 40°C.

2.4.2.24 Detection, Protection, Insulation and or Fighting of Fire

The Contractor shall provide all necessary measures of detection, protection, insulation and fighting of fire corresponding to all applicable codes and standards.

2.4.2.25 PV Module Mounting Structure (Solar Arrays)

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In order to get an optimized design for the PV Plant, the Contractor is free to choose the type of mounting structures and final arrangement on the Site and it shall be confirmed by the employer.

Regardless of the system selected, the Contractor shall consider the following:

- The solar arrays shall be prepared by leveling, compaction and grading. Compaction, improvement or replacement of the soil as determined by the ground investigations shall be carried out to provide the required bearing capacity for all the solar arrays to be deployed and equipment to be installed.
- The foundation design shall be chosen in accordance with Soil Test Report and shall be verified by Contractor's own geotechnical study and ground investigations of the PV Plant area.
- The findings of physical model tests to be carried out to determine the horizontal and uplift loadings likely to be exerted on structure due to highest wind with highest sand content in the area can be considered.
- The mounting structure shall be designed, so that it withstands all of the combined unfavorable loads described in section 6, Clause 2.4.2.2 under consideration of safety factors.
- The solar arrays shall be designed, manufactured and configured in accordance with a commercially proven design in such a way that the conversion of solar irradiation into electricity is based on high efficiency and achieves high availability and reliability.
- The lowest point of PV modules should consider the influence of wave run-up.
- Corrosion protection: Structure connection (nuts, bolts, washers, lock washers, etc.) shall be stainless steel or hot-dip galvanized steel. The Contractor shall take appropriate measures, if necessary, to protect the structure and foundation against corrosion due to salty air, dust and chemical aggressiveness for the expected lifetime of the plant.
- The PV module substructure shall be designed to withstand the continuously repeated washing of the PV modules.
- The Contractor shall demonstrate that his design of the substructure for the PV modules is able to withstand uplift and all weather-induced stress.
- All works shall be planned and done in accordance with the environmental regulations, the impact to the environment during time of construction and the PV Plant use.
- The mounting structure shall be designed in accordance with international and national standards.
- The mounting structure and the foundations shall be designed for a survivability 1 durability of at least 20 years.
- Deconstruction works at the end of lifetime of the PV Plant shall be minimized.
- The structure shall be designed to resist all imposed loads in all possible working conditions. This includes wind load derived from reference wind speed and considering local terrain factors as well as wind gust variations, temperature loads and all other expected live loads.

If a wind barrier shall be installed around the Site the suitability shall be adequately proven by wind channel tests and the design of the barrier needs to be defined in detail including structural verification of the barrier and its foundations. The installation of such system will require the approval of the Employer before start of construction.

Fixed Mounting System



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The scope of the PV module fixed mounting system shall comprise at least the following:

- The fixed mounting system shall provide an equally tilted fixed surface of the structures, allowing for an optimized orientation of the PV modules towards the sun.
- The mounting structure shall be adapted to the PV modules manufacturer's requirements with respect to recommended PV module installation of portrait or landscape orientation or long edge or short-edge respectively good accessibility of all module rows to minimize cleaning and maintenance efforts possibility for access of small vehicles between the module rows for mechanical cleaning or other necessary maintenance work. The gap between two module arrays should be equal to more than the height difference of the module array's lower and higher side.

2.4.2.26 Main Gate

Sliding metal gates of 1.8 meter high shall be constructed at suitable locations as directed by the Engineer.

PV power station main gate shall have the following minimum dimensions:

Height : 1.8metres , Width : 6.0metres

The Contractor shall submit design drawings showing details of the gates for approval of the Engineer.

2.4.2.27 Dyke construction

There are slopes near the sea level on the west and north sides of the photovoltaic area, which need to be protected. it is planned to adopt the scheme of R.C. grid plate for western slope protection, in particular, R.C. grid plate + precast plain concrete block base course + bagged gravel bedding course + geotextile, and stone block for bottom protection at the toe of slope. It is calculated that the thickness of the fence plate is about 0.3 m. For the other slopes, precast plain concrete block scheme is adopted, i.e. precast plain concrete block + bagged gravel bedding course + geotextile. The slope protection and typical cross section are shown in Figure 1-2:

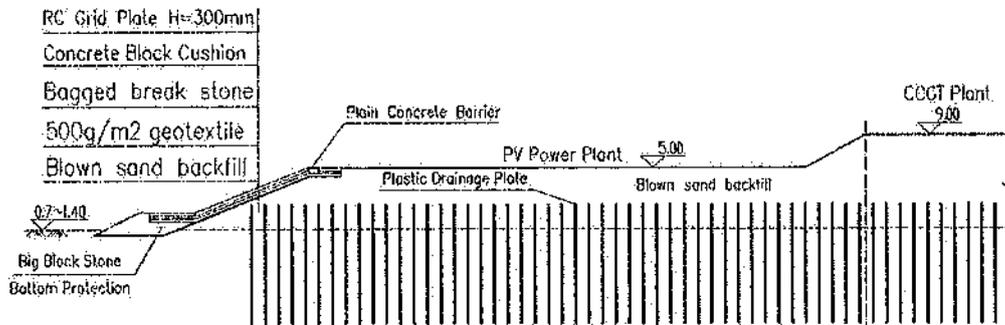
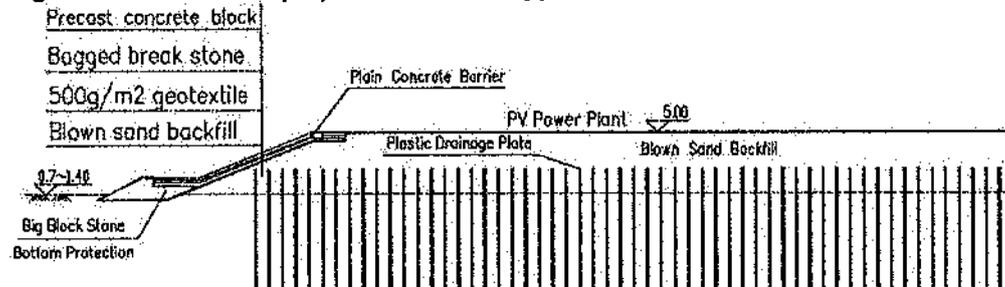


Figure 1: Western slope protection and typical cross section



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Figure 2: Northern slope protection and typical cross section

2.4.3 I&C Requirements

2.4.3.1 I&C Scope of Work

The scope of supply shall include - but not be limited to - the following systems and components:

- primary sensors, transmitters, actuators
- PV Plant Control and Monitoring System / Supervisory Control and Data Acquisition (SCADA) for the PV Plant, including all necessary software licenses
- Remote - PV Control System as Electrical Control and Monitoring System or as SCS independently working system, which is connected via serial interface with SCADA (if applicable)
- SCADA Human Machine Interface (HMI) with at least two operator stations, one on them combined operator/ engineering station (each with two LED screens, at least 21 inch) to supervise all systems from the PV Control Room in Service Building;
- RAID Station (Redundant Arrays of Inexpensive Disks) for Long Term Data Server routers
- RTU for Switchgear 132kV switchyard.
- PV Plant monitoring and control system and PV Plant performance calculation
- internal communication systems (telephone, LAN/ WAN system)
- GPS based clock systems
- Meteorological stations
- CCTV
- Telephone Facilities - the Plant shall be connected to the public telephone system via an Internet Protocol based private automatic branch exchange (IP - PABX) that shall be located in a PV Service Building forming part of the Plant.
- Connection of SCADA with Fire Alarm system
- Field testing equipment
- Instrument workshop equipment
- A high speed A3 color laser printer and two black and white A4 laser printers should be provided for report printing from any workstation
- Remote signal exchange and related works including RTU for signal exchange with PV plant switching station and with Employer
- Communication for monitoring and control with Employer. Communication will be maintained by Optical Fiber
- Training for all I&C systems and equipment shall be provided to the Employer’s management, operation and maintenance staff. The training shall cover hardware and software of all control systems like all SCADA components, PV Plant control and monitoring systems, meteorological stations, etc.
- Assistance and close cooperation for end-to-end test for data and signal transferred from PV Plant to Employer, which shall include data point tests, data communication and exchange tests

Contractor shall consider in its scope at least the following:

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- providing commissioning documentation
- providing all as built drawings including set points, interfaces, etc.
- Complete hardware and software documentation (including licenses and certificates).
- The SCADA system needs to achieve unmanned monitoring of the substation and remote monitoring in a remote monitoring center.

2.4.3.2 General

The following I&C requirements shall be provided:

- This specification does not relieve the Contractor of his responsibility for the basic design and execution of the instrumentation and control system. The rules of good engineering practice and the relevant approved standards and regulations shall be observed.
- The center line of instrument shall generally not be below 1000 mm and not be above 1500 mm; these heights refer to the standing level from the bottom of grade or platform. Instruments will normally be mounted on 2" pipe stand.
- All tubing and piping will be arranged and supported so as to minimize the transmission of strain and vibration to the instrument. All tubing and piping will be installed so that there is sufficient space for servicing and adjustment of the instrument. Piping, tubing, fittings and wiring will be arranged so that any instrument or device may be removed or serviced without disturbing the piping, tubing or wiring associated with other instruments.
- No single I&C failure shall:
 - cause any danger to personnel and the PV Plant
 - invalidate protection by inhibiting a trip
 - simultaneously trip a plant item and invalidate its auto-change-over; and
 - affect more than one control area
- A consistent instrumentation and control philosophy shall apply throughout the PV Plant and shall be implemented in terms of a range of equipment exhibiting a minimum diversity of type and manufacture. The objective shall be to standardize all measurement and control equipment throughout the Plant in order to rationalize operation, maintenance and reduce spares holding.
- Every safety related loop (if applicable on this PV Plant) has to be verified according to the standard IEC 61508, IEC 61511 that the requested and necessary Safety Integrity Level (SIL) is fulfilled for the individual loop. The Contractor has to assess all safety related loops to ensure compliance with the related requirements and has to make a protocol about these studies.
- The instrumentation and control equipment shall have high electro-magnetic and radio frequency interference immunity and shall not be affected by portable radio transmitters operated in the vicinity of the equipment. Any limitations shall be stated.
- All I&C equipment shall have enclosure classification not less than IP 54 according to IEC 60529 when mounted in an enclosed building and IP 65 for mounting outdoors. Control cubicles installed in air-conditioned rooms shall be at least IP 32.
- Sunshades shall be provided for all cubicles located outdoor and all cubicles shall be adequately ventilated or air-conditioned, if necessary, for operability.
- The Contractor shall ensure that the PV Plant design includes a CCTV system
- The number of cameras shall be according to O&M needs. The exact location of cameras and monitors must be fixed during the detailed design phase.

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- CCTV recordings shall be saved for at least six months.

2.4.3.3 Field Equipment

The requirements for field equipment are based on usage of conventional signal interfacing by I/O equipment. Indicators for local mounting will have 100 mm minimum dial size, if possible. Dial scales will be such that the normal operating range is in the middle third of the dial range. Dial thermometers may be used for local indication. They will be mounted in such a way so as to be vibration-free and independent of the machine foundations

For Transmitters in general, the following requirements shall apply:

- All transmitters shall have an impressed output signal of 4 - 20mA corresponding to zero to full range input. As far as possible, all transmitters shall be of SMART-type. This output signal range must be employed for all electronic, control and monitoring equipment throughout the entire station. The output signal of all transmitters must be independent of the burden of the transducer output circuit including cable resistance over a wide range.
- The removal of connected devices must not open the transducer output circuit or cause malfunction of this circuit
- In the case of failure and return of the supply voltage within a measuring circuit, no false signals endangering the system will be issued.
- Generally two wire transmitters shall be used. If for some special purposes (e.g. analyzers) 220 V AC power supply is required, the output circuit shall be isolated. All transmitters shall be individually fused; and
- Transmitters with accuracy class 0.5 or better must be used. The repeatability shall be within a range of $\pm 0.1\%$ of full span.
- All transmitters will be suitable for field installation and will have strong, moisture and dust proof cases with approved cable entries. All field installed transducers will have at least protection class IP 65. Electronic transmitters will have HART communication capability.
- Transmitters will be provided with all necessary isolating, vent and blow down valves and facilities will be provided for the connection of test instruments at the input and output of each transducer, to enable calibration to be carried out.
- All the transmitters installed at outside will be protected from direct sunlight
- It will be possible to check the output signal of the transducer while it is in service without interrupting the circuit. The transmitters will be furnished with local digital LCD type indicators with a scale of 0 to 100% of range. Minimum required accuracy will be $+0.10\%$ of span.
- Transmitters will be designed with provisions for zero and span adjustments. The sensing element will be of non-corrosive material.

2.4.3.4 Distributed Control System / Supervisory Control and Data Acquisition (SCADA)

General

- IEC 61724 have to be considered as guideline for measurement, data exchange and analysis
- IEC 61446 have to be considered as minimum requirement for system documentation, commissioning tests and inspection
- due to the requirements of availability, reliability and function, the control and monitoring tasks of main PV Plant processes shall be performed by a state of the art control system

the DCS shall achieve all functions of:

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- data acquisition
- control
- serial and/or hardwired communication to central inverters (PLC / manufacturer controller), weather stations, electrical control systems etc.
- human machine interface
- alarm signaling
- sequential event recording
- historical data archive and
- management reporting

In order to obtain a high availability and reliability of the PV Plant, the control system also requires a high availability. This shall be achieved by using single fault tolerant design for the centralized components, important sensors, which might affect the PV Plant availability in case of malfunction or used for protection, shall be provided in a redundant configuration.

System configuration shall be simple and flexible with regard to re-configuration of loop connection and display formats to suit changes in operational requirements. System software security, including data base configuration, controller loop tuning parameters shall be accessible by password.

All systems shall require minimum maintenance, and shall have comprehensive self-checking and self-diagnostic capabilities including self-test failure alarms etc. Mode of signal transmission shall be serial using standard protocols matching with DCS/SCADA, e.g. MODBUS, PROFIBUS, Foundation Field bus, etc.

Signal Input and Output Processing

- Dedicated hardware modules for input and output signal conditioning shall be provided. The process I/O shall be able to accept signals from conventionally available signal sources. (Binary signals, analog 4-20 mA signals).

Analogue I/O

- For the analogue inputs the system software shall check for signal integrity and if the input signal exceeds $\pm 5\%$ of the specified range the measurement shall be declared invalid. Analogue input modules shall also provide the power supply for the field transmitters; and
- Analogue inputs shall contain over range protection circuits to protect the equipment from ground faults or high voltage either in common or normal mode. Ground fault detection alarm shall be provided.

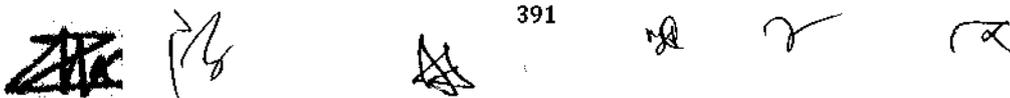
Binary I/O

- The binary input modules shall be provided for 24 V DC. Sense voltage to field contacts and input for proximity switches shall be provided by the DCS; and

Controls

- Special precautions shall be taken to provide maximum reliability for "Vital" control loops whose failure could result in a complete PV Plant shut down or threaten human life. These measures can be implemented as a redundant process interface, or using 2 out of 3 voting.

Data Highway Communication



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- The controller modules shall communicate with the workstations and with each other through a data highway. The data highway shall be coaxial or fiber optic cable, capable of data transmission over a distance of a minimum of 3000 m. Extension of the data highway shall be possible; and
- Operation of the single fault tolerant bus system shall be such that one failure of the highway shall not affect the operation of the PV Plant,
- Under no circumstances shall one single failure lead to an outage of the complete data system.

2.4.3.5 Human Machine Interface

- I&C systems shall be designed in such a way that the complete PV Plant can be remotely monitored and controlled from PV Plant Central Control Room (CCR) located within the Control Building.
- If necessary, the connection of an additional operator station in another room and in another building should be possible.
- An additional operator station should be provided with the same functionality as the PV Plant operation station. Local activities shall be not necessary.
- Operator stations with windows technique shall allow operating and monitoring the complete PV Plant
- The workstation shall be equipped with two 21 -inch (minimum) screens, mouse and keyboard.
- It shall be possible to display the process with corresponding graphic displays, control loop displays, electrical single line schematics, group displays, etc., all with dynamically updated process parameters on the VDU's. The system shall be able to create and to show displays like
- Overview display and process graphic displays
- Connection and production unit status alarm display; trend display (real time and historical trends); as well as logging reports.
- All necessary information concerning process behavior, control instrument and controller integrity for modulating control, sequential control and alarm function shall be immediately available at the operator station.
- Abnormal operating conditions and events in the PV Plant have to be annunciated. Under operation control, it shall be possible to print all or selected alarms on demand. A color laser printer shall be provided.
- The engineer's workstation shall allow system configuration, graphics development, control algorithm, report generation, system self-documentation functions, system monitoring functions (which show the result of self-diagnostic tests), system database load/save, diagnostics and failure analyses, reports, etc. In addition, it shall be possible to tune controllers, change limit set-points, view all loop variables, configure control systems, add and delete alarms;
- Data exchange to office and plant systems such as plant management systems, maintenance management system, document management systems, etc. shall be possible to request an extension.

2.4.3.6 Cyber Security

The PV Plant control systems are critical for the plant safety and operation. If degraded or sabotaged they put people, environment and assets at risk. The requirements to security are therefore high.

To ensure availability, confidentiality and integrity of the control system, at least the following points shall be taken into account:

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- be designed with security measures, segregation and availability to reflect the PV Plant requirements
- have measures to protect itself from unauthorized access from external systems including the corporate office data network
- have measures that enable secure remote operation according to process requirements; and
- have measures for disaster recovery.

All the measures shall be based on international standards like ISO 27001, IEC 62443 and ISA S99 directives.

2.4.3.7 External Data Communication

The interface coordination for the external data communication has to be carried out by the Contractor. The requirements shall comprise as a minimum:

- Interfaces for serial data communication shall be enabled for utilizing international standardized data transmission protocols (e.g. IEC 60870-5-101, IEC 60870-5-104, IEC 60870-5-102, IEC 61850, etc.) to communicate.
- Not less than 10% of the Interface equipment at each Interface installed shall be provided as excess capacity in order to allow for an additional 10% of signals without the need for additional Interface equipment;
- All telemetry signals shall be brought to the control system end units. The Contractor shall design the connection facilities to these end units in such a way that the performance requirements for the real time data exchange are met. A two-way connection to the end point units shall be provided for the PV Plant. The planning shall be brought to the Employer/NLDC system management unit for approval. During the design phase of the PV Plant connection facilities, the Contractor shall consider the security aspects in order to prevent breaking in the
- supervisory command and control system of Employer. The equipment shall be located in the Service Building of the PV Plant if not specified differently by Employer.
- Final signal list shall meet requirements of the Employer. These will be fixed during the detailed design phase.
- All operational information, PV Plant status, etc. shall be provided at the interface to Employer. The details have to be agreed during design phase.
- There will be an exchange of few signals from substation to the PV Plant Control System and few signals of the PV Plant Control System to the substation. The details have to be agreed during design phase (if applicable).
- The interface coordination has to be carried out by the Contractor.
- Interface to an overall fire detection system shall be considered.

2.4.3.8 Metering Requirements

- The metering (bidirectional) will be located at the evacuation switchyard.
- The Contractor has to provide the bidirectional operational meter located in the PV Plant substation according to the national regulations and norms.

2.4.3.9 PV Plant Control and Monitoring System and Performance Calculation

The PV Plant control and monitoring system shall consider measurements, evaluation of data, creation of models and performance calculations for at least:

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- PV strings
- junction boxes
- inverters
- transformers
- auxiliary loads
- MV switchgear
- meteorological stations; and
- Tariff meters. (According to the standards and requirements of Power Grid Company)

The followings signals shall be considered as minimum:

- Junction boxes located spread out in the solar field
- ◇ box temperature, as many as boxes in the PV Plant
- inverters located in the solar field
- ◇ P, Q, V, I in both in DC and AC; and
- ◇ temperature, cos phi.
- transformers located in Transformer Stations
- ◇ temperature; and oil pressure.
- ◇ auxiliary loads located in Transformer Stations as well as in other buildings or systems belonging to the PV Plant
- ◇ status of energy back up
- MV switchgear located Transformer Stations
- ◇ V, I
- ◇ fuse protection disconnecter, circuit breakers status
- Meters in LV and HV located in Service Building and at the Grid connection interface o instantaneous values: P, Q, cos phi, V and I; and
- ◇ cumulative: kWh, kVAr.

2.4.3.10 Meteorological Stations

Meteorological stations shall be installed at representative locations (on inverter site) throughout the PV plant. Each meteorological station shall contain as a minimum:

- one calibrated pyranometer secondary standard according to ISO 9060 classification to measure the global horizontal irradiance (GHI).
- two calibrated pyranometer secondary standard according to ISO 9060 classification to measure the global inclined irradiance on the planes of the array (POA) South PV sheds.
- Direct Normal radiation
- Shielded ventilated thermocouple to measure ambient temperature with a measurement accuracy of ± 1 °C (°C = Degree Celsius).
- Atmospheric pressure sensor



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- Resistance thermometer (e.g. Pt100) or equivalent to measure the temperature of modules (on the back of the PV modules) with a measurement accuracy of ± 1 °C.
- An anemometer to measure the wind speed at the site.
- The exact location of the anemometer will follow the recommendations from the supplier of the mounting system.
- Wind direction sensor.
- Dust fall verification for determination of soiling losses by means of two inclined reference cells on the planes of array (POA). The first reference cell shall be cleaned on a weekly basis and the second one shall be cleaned together with all the modules of the PV Plant
- Data logger

The meteorological stations, with their corresponding data loggers, shall be located at strategic point and shall be capable of collecting the data points at preset sample frequencies. The meteorological stations shall have capability of recording and storing environmental data without AC power for a minimum of ten (10) days.

Both the meteorological stations and the data loggers shall be tampering proof. The meteorological stations shall be integrated in the control system before commissioning. The Contractor shall provide a remote secure connection through the external internet line for data export to the main offices of the Employer at its HQ Office or any other entity that the Employer might designate. Format of the data transmission and interfaces shall be defined in agreement with the Employer.

2.4.3.11 Communication Equipment

Telephone System (voice and data)

- An Internet Protocol based telephone system (IP-PABX) shall be provided by the Contractor.
- Wall mounted telephones or desk telephones shall be provided for all technical / operational rooms of the PV Plant.
- A PV Plant internal LAN/ WAN system (e.g. for office work, maintenance and spare part management, control room to each security posts etc.) in accordance with the O&M requirements shall be provided in all relevant rooms of the PV Plant

2.4.3.12 Security and Surveillance Systems

The scope of supply shall include - but not be limited to - the following systems and components:

- intrusion deterrent system
- CCTV surveillance system
- access control system
- fire detection system; and command & control work station.

The design and supply of the detection system shall include:

- video analysis

The design and supply of the deterrent system shall include:

- the emergency address system including horns and local amplifiers

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- surprise lighting

The design and supply of the CCTV surveillance system shall include:

- fixed outdoor cameras
- dome cameras
- fixed indoor cameras
- work station and monitors and
- LED illuminators.

The number and type of cameras, their exact location must be fixed during the design phase.

The fire detection is to be made via smoke detectors located in the Service Building rooms, substation rooms and transformer stations.

The Access control system shall be designed and equipped to allow only authorized personnel to access the PV Plant and sensitive areas such as control room and surveillance room. Keypads and fingerprint devices shall be installed at the entrance of such sensitive rooms and entrance gates. Operator and security personnel shall be given a personal code.

2.4.4 Inspection Commissioning and Acceptance Testing

The requirements for inspection, commissioning and acceptance testing of the PV Plant are described below.

2.4.4.1 Inspection

Before each shipment of major equipment (PV module, Inverter, Transformer, HV and MV Switchgear), a factory acceptance test 1 pre-shipment inspection shall be carried out at the equipment's production facility on a sample of equipment by Employer's Engineers and / or by third party agency approved by the Employer. The Contractor shall provide a comprehensive description of such factory acceptance test pre-shipment inspection procedure, subject to the Employer's approval, which shall then be signed by the Parties and bindingly applied to a sample of all major equipment to be shipped.

The description of the factory acceptance test 1 pre-shipment inspection procedure shall include, but not be limited to, definition of:

- equipment batch and sample size and number of equipment that do not comply with the test to reject the whole batch
- an extensive list of visual inspection criteria (including, but not limited to, cell impurities, bubbles, cell gaps, cracked cells, backsheet damages, frame scratches, etc., as applicable)
- The rmographic inspection procedure to identify any defects in the electrical circuit of the modules
- maximum power determination procedure in order to verify compliance with the measurements stated in the manufacturer's flash list.
- The Engineer and Employer's authorized representative shall have the right to inspect and/or to test the Goods at Site and at manufacturer's premises to confirm their conformity to the Contract. The cost of performing any tests shall be borne by the Contractor, cost refers to PCC [GCC 38.2].
- Further inspections on the modules will be applied in accordance with Section 6, Clause 2.4.4.2.

2.4.4.2 Commissioning and Acceptance Testing

The Employer shall have the right to have their representatives present during all inspections and tests. The presence of Employers representatives during any inspection or test (or waiver by Employer of their right

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to witness any inspection or test) shall in no way relieve the Contractor of its responsibility for supplying the equipment in accordance with the scheduled dates.

This Clause describes the relevant DC and AC test procedures and the sequence of tasks for Commissioning, Provisional Acceptance Test, Annual Performance Review, and Final Acceptance Test of the PV Plant ("the Plant").

The Contractor shall be responsible for providing all supplies required for carrying out such tests, except for supplies required to be provided for such tests by the Employer.

All measurement uncertainties due to, for example, equipment inaccuracies etc. shall not be taken into account separately as they are already considered in the thresholds of provided formulas or guarantees.

The results of all tests shall be certified by the manufacturer, Contractor, independent agency or the Employer's Engineer as appropriate.

2.4.4.2.1 Definitions

All capitalized terms shall have the meanings given to them in the General Conditions of Contract (GCC) and the Particular Conditions of Contract (PCC, together the "Contract"). For purposes of this Clause, the following capitalized terms shall have the indicated meanings:

"Adverse Weather Conditions" mean instances of excessive climate and weather conditions measured by a weather station at the Site, but in any case more than 15 mm of rain per day or storm conditions that impede the Commissioning and or Provisional Acceptance Test.

"Annual Degradation" is the constant annual factor of efficiency loss for the given PV module technology.

"Annual Performance Review Certificate" means the certificate issued by the Employer to the Contractor to confirm the Annual Performance Review as defined in 2.4.4.2.7.

"Annual Performance Review" means the verification of the PV Plant performance in accordance with the provisions of Section 6, Clause 2.4.4.2.7.

"Commissioning" means all relevant tasks to be performed in accordance with the provisions of Section 6, Clause 2.4.4.2.

"Commissioning Certificate" means the certificate issued after all commissioning tasks have been performed successfully in accordance with the provisions of Section 6, Clause 2.4.4.2.5.

"Connection Infrastructure" means all required components needed for grid connection in the scope of the Contractor.

"Counter Flash Tests" means the measurement of the PV module peak power at the Independent Laboratory for a representative number of modules for the PV Plant.

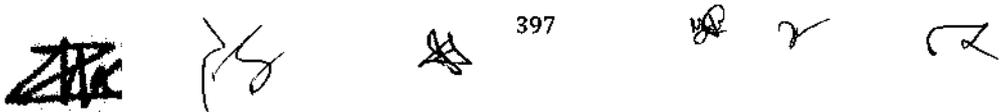
"Final Acceptance Certificate" means the certificate issued by the Employer to the Contractor to confirm Final Acceptance as defined in Clause 1 of the Contract.

"Final Acceptance Test" means the tests to be performed in accordance with the provisions of Section 6, Clause 2.4.4.2.8.

"Flash Peak Power" means the peak power of all installed and connected PV modules of the PV Plant in kWp according to the manufacturer flash list.

"Grid Code" means the national regulations for the grid management, as guideline in order to allow for evacuation of electricity from the Plant into the grid.

"Independent Laboratory" means IEC-accredited international testing laboratory, to be determined by the Contractor, subject to approval by the Employer and the Employer's Engineer, for performance of the Counter Flash Tests.

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"Installed Capacity" is the Nominal Peak Power of the aggregate PV modules in kWp, verified through Counter Flash Tests. In the event that there is a deviation in the results for the average of the PV modules according to Flash Peak Power, provisions of the capacity and price adjustment procedure shall be applied, as further defined in Section 6, Clause 2.4.4.2.9 and 2.4.4.2.10

"Interruption" means, in the case of the Provisional Acceptance Test of the PV Plant, the shutdown of any facility forming part of the Plant preventing the Plant from delivering electrical energy.

"Maximum Capacity Price Adjustment" means an amount equal to 5% of the Contract Price.

"Minimum Acceptance Criteria" means the minimum acceptance criteria in respect of Performance Guarantees and Installed Capacity for Provisional Acceptance as specified in Contract Appendix 8 of Section 4 of the Bidding Documents.

"Nominal Peak Power" means the nameplate capacity of the PV modules in kWp.

"Capacity Price Adjustment" means adjustment of the Contract Price pursuant to differences between Revised Guaranteed PV Plant Capacity and agreed upon Guaranteed PV Plant Capacity, as defined in clause 2.4.4.2.10.

"Peak Power Certificate" means the certificate to be issued by the Employer's Engineer confirming the verification of the Installed Capacity in accordance with Section 6, Clause 2.4.4.2.9.

"Defects Liability Period" will be two (2) years as defined in Clause 1 of the Contract.

"Provisional Acceptance Certificate" means the certificate issued by the Employer to the Contractor to confirm Provisional Acceptance. The Provisional Acceptance Certificate is identical with the Operational Acceptance Certificate.

"Provisional Acceptance Test" means the test to be performed in accordance with the provisions of Section 6, Clause 2.4.4.2.6.

"Provisional Acceptance Testing Period" means the amount of days necessary for the testing as described in Section 6, Clause 2.4.4.2.6.

"Completion Certificate" means the certificate to be issued by the Employer's Engineer confirming the successful Pre-Commissioning of the Plant by the Contractor pursuant to the provisions of the Contract.

2.4.4.2.2 Test procedures

The Contractor's technical personnel, with the assistance and supervision of equipment manufacturer(s), will be responsible for complete Commissioning of the PV Plant.

The Commissioning of the PV Plant includes the following procedures:

- Hot and Cold Commissioning testing outlined in Contractor procedures
- tests and inspections required by codes, national standards, and equipment manufacturers
- determination of the Installed Capacity of the PV Plant according to the procedure described in Section 6, Clause 2.4.4.2.9.

All measurements and testing procedures, such as string testing and I-V curve measurement results, will be provided completely in electronic form and as a hard copy. Documentation from all procedures of Commissioning and testing tasks, measurements, and results will be submitted to the Employer and the Employer's Engineer.

The overall testing program for the PV Plant shall consist of the following:

- Commissioning, including the Connection Infrastructure
- Provisional Acceptance Test

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2.4.4.2.3 Cold Commissioning

The verification of the Commissioning tests will be based at least on the latest published testing procedure IEC 62446: Grid-connected photovoltaic systems - Minimum requirements for system documentation, Commissioning tests, and inspection, for all electrical Commissioning. The verifications shall include, but not be limited to, the following equipment to be tested:

- PV modules
- PV modules support structure/tracking system
- support structure foundations
- string cabling
- LV DC cabling between combiner boxes and inverters
- combiner boxes
- inverters
- LV AC cabling between inverters and transformers
- transformers
- transformation, protection, distribution centers, and MV lines
- piping (where applicable), cable trays, inspection chambers, wiring, etc. both for DC and AC
- power, data transmission, and all other required transmission lines, including junction boxes, fuses, and all other required electrical equipment
- external interconnection cabinets
- internal connections and Connection Infrastructure with external facilities in accordance with
- the relevant IEC and national norms as described in Section 6 of the Bidding Documents.
- meteorological stations and monitoring system
- low-voltage installation, civil works, and medium-voltage installation
- security system
- all measurements as defined and described in IEC 62446
- all necessary tests at the MV interface in coordination the Employer

The Cold Commissioning tests shall include the measurement of 100% of the open circuit voltage (V_{oc}) and the short circuit current (I_{sc}) of the PV module strings. The minimum irradiance on the plane of array for the V_{oc} and I_{sc} measurements is 600 W/m^2 . At least 10% of the strings of the PV Plant shall be measured with the presence of the Employer. The selection of strings shall be agreed between the Contractor and the Employer on a case-by-case basis, taking into account the fact that the sample shall be representative of all the sections of the PV Plant. The adequacy of the measurement devices proposed by the Contractor in terms of measurement uncertainty, calibration, etc. will be assessed and must be confirmed by the Employer's Engineer prior to the start of the tests. A report with the measurement results of 100% of the strings will be presented by the Contractor in digital form as an Excel file.

The conditions for the measurements are as follows:

The V_{oc} test will be considered as passed if all the $V_{oc,string}$ on the tested strings satisfy the following condition:

$$0.95 \times V_{theo} \leq V_{oc,string} \leq 1.05 \times V_{theo}$$

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Where V_{theo} is the theoretical open circuit voltage for the strings and calculated as follows:

$$V_{theo} = n \times V_{oc} \times [1 + (T_{mod} - T_{STC}) \times C_{t,abs}]$$

whereby:

n is the number of PV modules of the tested string [-].

V_{oc} is the open circuit voltage of the PV module as of the PV module manufacturer data sheet [V]

T_{mod} is the temperature recorded on a PV module representing the tested string [°C], measured with a precision better than 1%.

T_{STC} is the temperature under standard test conditions and equal to 25°C.

$C_{t,abs}$ is the absolute value of the power temperature coefficient as of the PV module manufacturer data sheet [V/°C].

The I_{sc} test will be considered as passed if all the I_{sc} , string on the tested strings satisfy the following condition:

$$0.90 \times I_{theo} \leq I_{sc,string}$$

Where I_{theo} is the theoretical short circuit current for the strings calculated as follows:

$$I_{theo} = I_{sc} \times \frac{H_{POA}}{H_{STC}}$$

I_{sc} is the short circuit current of the module as of the PV module manufacturer data sheet.

H_{POA} is the instantaneous irradiation on the plane of array of the tested PV module string [W/m²], measured with a pyranometer with 2% measurement uncertainty.

H_{STC} is the irradiance under standard test conditions and is equal to 1000 W/m².

Any possible anomalies shall be checked immediately by the Contractor as they could result from, for example, faulty connections or damage in the junction boxes or diodes. The faulty connection must be identified and repaired or substituted. Once the repair has been completed, the short circuit test will be repeated.

2.4.4.2.4 Hot Commissioning

Once the PV Plant is energized (this may require a dump load during testing), the Contractor shall demonstrate that the overall system and equipment operates in accordance with the following:

- equipment manufacturer specifications
- specifications of the Contract
- national Grid Code and other relevant national and international norms and standards.

For hot Commissioning testing, the following supplies and equipment will be commissioned / tested:

- DC operating current tests
- inverters
- combiner boxes
- low-voltage boards
- internal connections and interconnections with external facilities, whether mechanical or electrical
- monitoring system and/or control instruments and devices

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- telecommunication system for remote access
- meteorological stations and monitoring system
- safety devices
- medium-voltage switchgears and cubicles
- transformers
- security system
- grounding and lightning protection system
- MV interface, including, but not limited to:
- MV equipment.

Likewise, it will be verified that any equipment and material that may compromise the proper and safe operation of the PV Plant has been removed.

2.4.4.2.5 Completion of Commissioning

After successful Commissioning for the PV Plant, the Contractor will deliver all results and documentation to the Employer.

The Commissioning Certificate will be issued by the Employer once successful completion of commissioning has been verified.

2.4.4.2.6 Provisional Acceptance Testing and Reliability Run

2.4.4.2.6.1 Purpose

The Provisional Acceptance Test of the Plant shall be for the purpose of (i) demonstrating the achievement of guaranteed values, (ii) demonstrating the reliable and safe operation of the equipment, systems, and facilities (Reliability Run Test as defined in PCC[GCC1.1(yy)]), and (iii) being a condition precedent to the achievement of the Operational Acceptance of the Plant.

After successful completion of the items described in Section 6, Clause 2.4.4.2.6.4, the Contractor shall be allowed to prepare the facilities for the Provisional Acceptance Test.

The Provisional Acceptance Test shall be carried out for the entire Plant, including related equipment and systems.

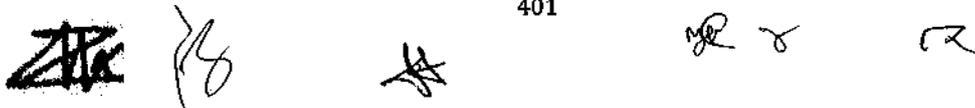
The Contractor shall notify the Employer that the Plant is ready for the Provisional Acceptance Test and that the instrumentation for the test is installed, commissioned, and checked. The supporting documentation, including instrumentation, calibration, and commissioning certificates, shall be provided to the Employer together with the notification. Should all documentation be acceptable, within five (5) days thereafter the Provisional Acceptance Test shall be started, when the weather conditions allow the test to be started, that is, when no Adverse Weather Conditions prevail.

The Provisional Acceptance Test shall be carried out by the Contractor under the supervision of the Employer, involving representatives from the Employer.

The Provisional Acceptance Test shall be evaluated by the Contractor and the results of the Provisional Acceptance Test shall be reviewed by the Employer.

When the Provisional Acceptance Test is passed successfully (as specified in Section 6, Clause 2.4.4.2.6.2, 2.4.4.2.6.3 and 2.4.4.2.6.4) the Provisional Acceptance Certificate will be issued to the Contractor by the Employer.

If the Provisional Acceptance Test is not passed successfully, the Contractor has the obligation for remediation and to repeat the Provisional Acceptance Test within a maximum period of three (3) months.

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Until successfully passing the Provisional Acceptance Test, delay damages apply up to the maximum amount of delay damages according to Sub -Clause 41.2 of the Contract. In the event that the maximum amount of delay damages is reached without successfully passing the Provisional Acceptance Test, the Employer has the right to terminate the Contract in accordance with the provisions of Clause 67 of the Contract.

2.4.4.2.6.2 Provisional Acceptance Test Procedure

The Contractor shall submit to the Employer a detailed test procedure for the Provisional Acceptance Test in writing two (2) months prior to the proposed commencement of the Provisional Acceptance Test in accordance with the provisions of Section 6, Clause 2.4.4.2. The procedure must be approved by the Employer.

The test procedures shall include:

- Provisional Acceptance Test detailed procedure
- description of instrumentation to be used, including accuracy
- method of data recording
- forms of test records and of test report.

The Provisional Acceptance Test shall be performed for the entire PV Plant, evacuation infrastructure and grid connection.

2.4.4.2.6.3 Instrumentation

The instrumentation for the Provisional Acceptance Test for the PV Plant will consist of at least two (2) meteorological stations, each consisting of:

- two (2) calibrated pyranometer to measure the global inclined irradiance on the plane of the array (POA) with a target measurement uncertainty of 2% and secondary standard according to ISO 9060 classification [W/m²].
- two (2) calibrated pyranometer to measure the global horizontal irradiance (GH) with a target measurement uncertainty of 2% and secondary standard according to ISO 9060 classification [W/m²].
- a shielded, ventilated thermocouple to measure ambient temperature with a measurement accuracy of $\pm 1^{\circ}\text{C}$
- a resistance thermometer (e.g. Pt100, Pt1000) or equivalent to measure the temperature of modules (on the back of the PV modules) with a measurement accuracy of $\pm 1^{\circ}\text{C}$
- an anemometer mounted on a mast to measure the wind speed at the Site. The exact location and height of the mast will follow the recommendations from the structure supplier (if applicable).

For the data collection and evaluation of the meteorological data from the stations:

- Data will be collected by station, loggers, and instruments with a scan rate of one minute.
- All collected data will be averaged into 15-minute records.
- The records will be used for Provisional Acceptance Testing and for the Annual Performance Review.

The values of the pyranometers of different meteorological stations shall be averaged arithmetically. In case that the daily sum of the irradiation is more than 3% deviating between both pyranometers, the day shall be excluded and the test for that day repeated.

All pyranometers have to be cleaned on a daily basis.

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The following energy and tariff meters (calibrated and approved according to BPDB and PGCB standard) are required:

- Tariff meters at the PV Plant substation (HV side) [Operational Meters]
- Tariff meters at the grid connection point
- DC energy meters at the input side of all central inverters.

2.4.4.2.6.4 Requirements for Starting the Provisional Acceptance Testing

The following requirements must be fulfilled prior to the start of the Provisional Acceptance Test:

- The Commissioning Certificate has been issued, which relates to the successful execution of Commissioning as described in Section 6, Clause 2.4.4.2.5.
- The Peak Power Certificate has been issued, which relates to the verification of the Installed Capacity of the PV Plant in accordance with Section 6, Clause 2.4.4.2.9.
- Upon issuance of the Commissioning Certificate, the Provisional Acceptance Test must be started within a maximum of twenty (20) days if not otherwise agreed between Contractor and Employer.
- The Provisional Acceptance Test Procedure as described in Section 6, Clause 2.4.4.2.2 has been published and agreed by the Contractor, the Employer and the Employer's Engineer.
- Instrumentation for the tests as described in Section 6, Clause 2.4.4.2.6.3 has been installed, commissioned, and calibrated, and data is available in the monitoring system.

2.4.4.2.6.5 Irradiance and Availability Criteria for the Provisional Acceptance Test and Reliability Run Test

The test will be carried out for at least six (6) days (the Provisional Acceptance Testing Period) with the following criteria:

- At least six days with irradiance measured on the plane of the array greater than 400 W/m² for 6 continuous hours
- For the avoidance of doubt, these days may be the same as those in the first condition (400 W/m² for 6 continuous hours)
- In the event that the six days are not reached with the required irradiation levels, the Provisional Acceptance Testing Period will be extended until the irradiation criteria are achieved.
- If the Reliability Run Conditions as per GCC Clause 1.1 is not fulfilled within the period of Provisional Acceptance Test, the Reliability Run Test will be extended as required.
- Availability of the PV Plant and the grid temporarily use 98.5%. In the event of unavailability, the Provisional Acceptance Testing Period will be extended accordingly by the relevant number of days.

2.4.4.2.6.6 Provisional Acceptance Guarantee

During the Provisional Acceptance Test, the Contractor shall demonstrate that the PV Plant, including related equipment and systems, achieves the Guaranteed PV Plant Capacity (AC) and Weather Adjusted Yield guaranteed in the relevant schedules of Section 4 and Section 6 of the Bid Documents for the month under consideration.

2.4.4.2.6.7 Evaluation Methodology of the Provisional Acceptance Test

Guaranteed PV Plant Capacity (AC) shall be verified with the actual measurements made during the test using the procedure and calculation formula provided in 2.4.4.2.6.9.

2.4.4.2.6.8 Definition of the Yield at the Provisional Acceptance Test

Not applicable.

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2.4.4.2.6.9 Provisional Acceptance Test Calculation

The Provisional Acceptance Test will be considered successful if, for the Provisional Acceptance Testing Period, the following are fulfilled:

PV Plant Capacity (AC):

During the test period the PV Plant Capacity shall be calculated based on global solar irradiance (1000 W/m²) at panel tilt angle. The PV Plant Capacity shall be calculated as follows:

$P_{AC} = \text{PV Plant Capacity (MW)}$

$P_x = \text{Power Output during test period (MW)}$

$I_x = \text{Irradiance at panel tilt angle during test period (W/m}^2\text{)}$

$E_E = \text{Exported Energy (kWh)}$

$P_{AC} = (P_x / I_x) * (1000 \text{ W/m}^2)$

Measured value of P_x and I_x shall be recorded every 30 minutes for at least 4 consecutive hours during the test hours and individual value of P_{AC} shall be calculated from the table given below:

PV Plant Capacity (AC) Calculation:

Time (Minutes)	E_E (kWh)	P_x (MW)	I_x (W/M ²)	P_{AC} (MW)	Remarks
	From Tariff Meter	Average Power of previous 30 minutes calculated from E_E	From Irradiation Measurement Device (Average of previous 30minutes)		
0					
30					
60					
90					
120					
150					
180					
210					
240					
270					
300					

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360					

To determine the PV Plant Capacity (AC) of the Project, the above readings of P_{Ac} shall be averaged and shall be greater than the Guaranteed PV Plant Capacity (AC).

2.4.4.2.6.10 Requirements for the Issuance of the Provisional Acceptance Certificate

The Provisional Acceptance Certificate will be issued by the Employer once the following items are fulfilled:

- The Cold and Hot Commissioning Tests for the PV Plant have been successfully executed as described in Section 6, Clause 2.4.4.2.3 and 2.4.4.2.4.
- The Provisional Acceptance Test for the PV Plant is successfully passed as described in Section 6, Clause 2.4.4.2.6.9.
- The punch list has been prepared and delivered by the Contractor and the Employer's Engineer has approved the punch list items and determined the value thereof, which must be remedied within one month from the issuance of the Provisional Acceptance Certificate. The value of the punch list items shall not exceed 3% of the Contract Price.
- The Reliability Run has been successfully completed, the Reliability Run has not been successfully completed or has not been carried out for reasons not attributable to the Contractor.
 - The Final Documentation has been delivered by Contractor.
 - The O&M Manual has been delivered by the Contractor.
 - Liquidated Damages have been paid if applicable.
 - The Initial Inventory has been delivered to the Site.

2.4.4.2.7 Annual Performance Review

2.4.4.2.7.1 Purpose

The Annual Performance Review of the PV Plant shall be for the purpose of (i) demonstrating the achievement of the Annual PR Guarantee during the Defects Notification Period of the PV Plant, and (i) reliable, stable, and safe operation of the PV Plant. The Annual Performance Review will be performed for the first and second year of plant operation from the issuance of the Provisional Acceptance Certificate.

When the Annual Performance Review is passed successfully (as specified in Section 6, Clause 2.4.4.2.7. 4) the Annual Performance Review Certificate will be issued to the Contractor by the Employer.

If the Annual Performance Review is not passed successfully (as specified in Section 6, Clause 2.4.4.2.7.4) non-performance damages must be paid according to Section 6, Clause 2.4.4.2.7.6.

2.4.4.2.7.2 Requirements for the Annual Performance Review

The following requirements must be fulfilled prior to the start of the Annual Performance Review:

- The Provisional Acceptance Test has been successful and the Provisional Acceptance Certificate has been issued.
- For the first Annual Performance Review, the issuing of the Provisional Acceptance Certificate is one (1) year previously.
- No punch list items are pending.

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2.4.4.2.7.3 Annual Performance Review Calculation

The Annual Performance Review comprises the verification of the performance of the PV Plant on a yearly basis. For the comparison of the measured PR and the guaranteed PR, a temperature correction approach must be followed. The PR_{measured} will be corrected with the actual ambient temperature, which may deviate from the assumptions of a typical meteorological year as the basis of the PVsyst simulations (reference values). The correction for the Annual Performance Review takes the annual values into account (both measured and reference). No further reduction with respect to the Annual Degradation δ must be made as the measured electricity generation already accounts for module degradation. The Annual PR Corrected for the first year is consequently defined as:

$$PR_{\text{corrected}}^A = PR_{\text{measured}}^A \times [1 - (T_{\text{amb,measured}} - T_{\text{amb,ref}}) \times c_t]$$

whereby:

$T_{\text{amb,measured}}$ = average ambient temperature measured [°C]

$T_{\text{amb,ref}}$ = average ambient temperature from the typical meteorological year [°C]

c_t = negatively defined power temperature coefficient as of the module manufacturer data sheet [-x%/°C].

2.4.4.2.7.4 Compare Annual $PR_{\text{corrected}}$ with Annual $PR_{\text{guarantee}}$

The Annual Performance Review will be considered successful if, for the relevant year of consideration, the following is fulfilled:

$$PR_{\text{corrected}}^A \geq PR_{\text{Guarantee}}^A$$

for each year of the Defects Notification Period.

2.4.4.2.7.5 Requirements for the Issuance of the Annual Performance Review Certificate

The Annual Performance Review Certificate will be issued once:

- The requirements as described in Section 6, Clause 2.4.4.2.7.2 are fulfilled.
- The Annual Performance Review is considered successful as described in Section 6, Clause 2.4.4.2.7.4.

2.4.4.2.7.6 Liquidated Damages

The Contractor shall pay non-performance damages to the Employer if the Performance Ratio measured during the Annual Performance Review is less than the Annual PR Guarantee without further consideration of measurement uncertainties:

Damages shall be paid if: $PR_{\text{measured}} < PR_{\text{guaranteed}}$

For each percentage that the Annual PR Corrected ($PR_{\text{corrected}}$) is below the Annual PR Guarantee ($PR_{\text{Guarantee}}$), an amount equal to 0.5% of the Contract price shall be payable by the Contractor to the Employer.

It is intended that, under no circumstances, will the correction mechanism lead to a payment from the Employer to the Contractor.

The non-performance damages are payable in the proportions of currencies in which the Contract Price is payable.

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The maximum amount of non-performance damages for the Annual PR Guarantee shall be five percent (5%) of the Contract Price.

2.4.4.2.8 Final Acceptance Test

2.4.4.2.8.1 Purpose

The Final Acceptance Test of the PV Plant shall be for the purpose of (i) demonstrating achievement of the PR Guarantee for the last year of the Defects Notification Period of the PV Plant, and (ii) reliable, stable, and safe operation of the PV Plant.

When the Final Acceptance Test is passed successfully (as specified in Section 6, Clause 2.4.4.2.8.4) the Final Acceptance Certificate will be issued to the Contractor by the Employer.

If the Final Acceptance Test is not passed successfully (as specified in Section 6, Clause 2.4.4.2.8.4) non-performance damages related to future losses must be paid according to Section 6, Clause 2.4.4.2.7.6.

2.4.4.2.8.2 Requirements for the Final Acceptance Test

- The Annual Performance Review has been successful for the first year of the Defects Liability Period or relevant liquidated damages have been paid according to Section 6, Clause 2.4.4.2.7.6.
- The issuing of the Provisional Acceptance Certificate is two (2) years previously.
- The Initial Inventory has been replenished as per Section 6, Clause 2.4.5.

Thermographic analyses have been performed with IR camera for all PV modules and electrical connections in order to detect possible hot spots. PV modules with temperature anomalies have been replaced and electrical connections with temperature anomalies have been renewed, at the Contractor's sole expense.

2.4.4.2.8.3 Final Acceptance Test Calculation

The Final Acceptance Test Calculation is equal to Section 6, Clause 2.4.4.2.7.3.

2.4.4.2.8.4 Compare Final PR_{corrected} with Final PR_{Guarantee}

Final Acceptance for the second year of the Defects Liability Period will be deemed achieved if.

$$PR_{corrected}^F \geq PR_{Guarantee}^F$$

2.4.4.2.8.5 Requirements for the Issuance of the Final Acceptance Certificate

The Final Acceptance Certificate will be issued once:

- The requirements as described in Section 6, Clause 2.4.4.2.8.2 are fulfilled
- The Final Acceptance Test is considered successful as described in Section 6, Clause 2.4.4.2.8.4.

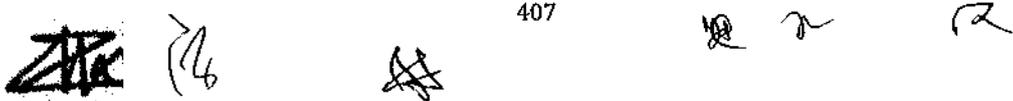
2.4.4.2.8.6 Liquidated Damages

The calculation of Liquidated Damages at Final Acceptance is equal to Section 6, Clause 2.4.4.2.7.6.

2.4.4.2.8.7 Liquidated Damages to Indemnify Future Losses

Further, to indemnify Employer from future losses which may occur in the next eighteen (18) years of operation of the Plant if the Performance Ratio measured during the Annual Performance Review at the end of second year of Defect Liability Period is less than the Annual PR Guarantee without further consideration of measurement uncertainties:

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Damages shall be paid if: $PR_{\text{measured}} < PR_{\text{guaranteed}}$

For each percentage that the Annual PR Corrected ($PR_{\text{corrected}}$) is below the Annual PR Guarantee ($PR_{\text{Guarantee}}$), an amount equal to 0.5% of the Contract price shall be payable by the Contractor to the Employer.

It is intended that, under no circumstances, will the correction mechanism lead to a payment from the Employer to the Contractor.

The non-performance damages are payable in the proportions of currencies in which the Contract Price is payable.

The maximum amount of non-performance damages for the Future PR Guarantee shall not be limited by the maximum amount specified in Clause 2.4.4.2.7.6 above.

2.4.4.2.9 Capacity Adjustment Procedure

A sample of 100 (one hundred) PV modules randomly selected may be submitted, at the Employer's discretion, to the Counter Flash Tests as described in the following. The Parties agree that the Contract Price, as determined on the basis of the aggregate Nominal Peak Power of the PV Plant, will be adjusted on the basis of the Installed Capacity, in accordance with the procedure described in Section 6, Clause 2.4.4.2.10, and following capacity adjustment formula, as adjusted pursuant to the Counter Flash Test (as described below):

(1) Installed Capacity = \sum Flash Peak Power as adjusted here under:

- At least ten (10) days before the delivery date of each shipment of the PV modules to the Site, the Contractor will send to the Employer a notice pointing out, in relation to the relevant PV modules, their identification number, Nominal Peak Power, and Flash Peak Power.
- Within five (5) days after the delivery date of the last shipment of the PV modules to the Site, the Contractor, the Employer, and the Employer's Engineer will meet to calculate the aggregate Flash Peak Power of the PV modules installed in the PV Plant and the applicable Capacity Price Adjustment.
- The outcome of the calculation as adjusted pursuant to the provisions of below will be documented on a certificate to be issued by the Employer's Engineer (the Peak Power Certificate).

The results of determination of the Flash Peak Power shall be verified by way of performance of Counter Flash Tests at the Independent Laboratory. The Counter Flash Tests shall be performed as follows:

- The PV modules for the Counter Flash Tests shall be randomly selected by the Contractor from each shipment of PV modules, subject to approval of the Employer's Engineer. The selected PV modules may be delivered to the Site before they will be sent to the Independent Laboratory or they will be sent directly to the Independent Laboratory from the factory. The Counter Flash Tests must comply with the following conditions:
 - ❖ Solar simulators (flashers) should be rated as class AAA according to IEC 60904-9.
 - ❖ The PV modules should be given sufficient time to adjust to ambient temperature, bearing in mind that the output power error is approximately 0.5% per °C. The uniformity of temperature distribution shall be verified and a minimum of two temperature sensors shall be used.
 - ❖ Both types of high-efficiency rear-contact and HIT cells c-Si based PV modules are usually highly capacitive. Thus, sweep-time effects can influence the output power measurements. In order to verify such an effect, a sweep in both directions (I_{sc} to V_{oc} and vice versa) should be performed, as

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mentioned in IEC 60904-1. The divergence of the two IV curves gives an indication whether capacitive effects exist for given measurements conditions. In general for high-efficiency c-Si based modules the use of long pulse above 100ms and multi-flash techniques are recommended.

- The Parties hereby agree that there is an uncertainty (hereafter as“UCT”) associated with the Counter Flash Tests, which will be determined by the Independent Laboratory, but which should not lie above 2.5% for mono-crystalline modules.

Pursuant to the outcome of the Counter Flash Tests:

- In the event that the difference between the average of the Counter Flash Tests and the average of the Flash Peak Power is less than or equal to UCT, the Flash Peak Power will be used to determine the Installed Capacity.
- In the event that the difference between the average of the Counter Flash Tests data and the average of the Flash Peak Power data is greater than UCT but less than two times UCT, the Flash Peak Power will be adjusted based on the Counter Flash Tests results.

The adjustment factor will be equal to the difference in the Flash Test results minus half of UCT.

(In other words, the adjustment factor = $[(5 \sum \text{Average Counter Flash Test Results} - \sum \text{Average Flash Peak Power}) / \text{Average Flash Peak Power}] + \text{UCT} / 2$)

The adjusted Flash Peak Power results will be used to determine the Installed Capacity as set forth in the formula above.

Revised Guaranteed PV Plant Capacity (Item 1, Table ELI-6.1) shall be calculated from this revised Installed Capacity using the Guaranteed Mean Performance Ratio for Year 0 (from Table ELI-6.2).

- In the event that the difference between the average of the Counter Flash Tests data and the average of the Flash Peak Power is greater than two times UCT, the Employer will have the option to reject the corresponding shipment and the Contractor shall have to demount any PV modules already installed on the Site from said shipment at its sole cost and expenses. For the avoidance of doubt, in any such case, the Contractor shall not be entitled to any increase and/or adjustment to the guaranteed time lines and/or Price.

In addition to the above, in the event that the Counter Flash Test reveals systemic material faults comprising a material defect in a statistically significant proportion of PV modules tested, considered by the Independent Laboratory to affect energy production, safety, or conformance with

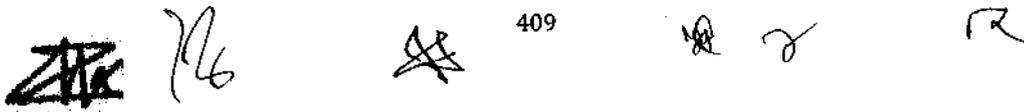
PV modules certification (under IEC 61215 or equivalent regulation), the Parties shall agree on the actions that need to be taken, including rejecting the applicable shipment (in which case the provisions of Sub-Clause (C) above shall apply) and any technical instructions to the manufacturing personnel to minimize the probability of reoccurrence of such faults in the future.

2.4.4.2.10 Price Adjustment Procedure

If the Revised Guaranteed PV Plant Capacity calculated as described in Section 2.4.4.2.9 of the PV Plant is lower than the agreed upon Guaranteed PV Plant Capacity (term 1 of Table ELI-6.1, Section 4), a Capacity Price Adjustment must be performed.

The Capacity Price Adjustment will be equal to the reduction of the Plant's Revised Guaranteed PV Plant Capacity in [%], multiplied by the Contract Price as defined in the Contract:

$$\Delta \text{Price} = (\Delta \text{Capacity} / \text{Guaranteed PV Plant Capacity}) \times \text{Contract Price}$$

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ΔPrice: is the applicable Capacity Price Adjustment

ΔCapacity: is the difference between the agreed upon Guaranteed PV Plant Capacity (Item 1 of Table ELI-6.1, Section 4) and the Revised Guaranteed PV Plant Capacity calculated using the procedure described in Clause 2.4.4.2.9 above.

The Maximum Capacity Price Adjustment shall be five percent (5%) of the Contract Price. If the Maximum Capacity Price Adjustment is exceeded, the Employer will be entitled to terminate this Contract in accordance with the provisions of Clause 67 of the Contract.

2.4.4.2.11 Liquidated Damaged on Completion Time Guarantee

Refer to SCC, Clause 26.

2.4.5 Initial Inventory

The Contractor shall be responsible for initial supplies of mechanical, electrical and I&C equipment as well as store and office equipment not specifically mentioned below, but necessary for the reliable operation and maintenance of the Plant, such as:

- consumables for commissioning, testing and during the Defects Notification Period of the PV Plant.
- spare parts for at least the Defects Notification Period of the Plant.
- special tools and equipment for maintenance.

2.4.5.1 Spare Parts and Consumables

The Contractor shall provide all spares necessary for discharging his responsibilities in carrying out the work, including commissioning and testing and during the warranty period. The Contractor shall ensure that he has prompt access to the spares to avoid delay to completion, commissioning or loss of generation.

All spare parts shall be directly interchangeable with the corresponding parts installed in the Plant and shall meet the requirements of the specifications of the Plant

Spare parts comprise all disciplines of civil, mechanical, electrical and I&C works and shall be in compliance with Table below (but not limited to):

Spare part	Quantity
Sensors	
Pyranometers	4
Ambient temperature sensor	2
Module temperature sensor	2
Data logger (complete)	1
Others	
SCADA system	key components: 2

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Security system	key components: 2
Network interface	key components: 2
Cooling system in cabins/rooms	key components: 2

Any spare parts used during the Defects Notification Period shall be promptly replaced by the Contractor. Spares shall be warranted during the Defects Notification Period for the original Plant.

2.4.5.2 Special Tools and Equipment for Maintenance

All the special tools and other equipment that are necessary for the overhaul, maintenance and adjustment of the whole Plant facilities and equipment shall be included in the Contractor's scope of supply. The Contractor shall provide two (2) sets of special tools. Corresponding toolboxes and tool cabinets shall also be provided by the Contractor.

All needed machinery, electrical and other equipment as well as vehicles needed for regular services and maintenance of the Plant shall be provided by the Contractor.

2.4.6 Performance Guarantee

The capacity of the DC side device shall be 192.78MW, and the capacity of the network side installation and access shall be 160MWac. The Contractor shall ensure that the first year PR of the Project is not less than 82.77%

2.4.7 Training Program

The Contractor is required to carry-out a Training Program for the personnel of the Employer during construction and operation phase. Employer will select several employees for the PV power plant.

The training has to be carried out in Manufacturer's premises (for a total of twenty (20) man-months) and "on the work" during the 2-year O&M period and cover all aspects of O&M.

The Contractor shall submit, within four months of the Contract Effective date, a detailed training plan including scope and timing for review by the Employer. The Contractor shall submit, two months prior to the start of each classroom lesson, a Course Description and Lesson Plan for review by the Employer. The training program shall be coordinated with pre-commissioning and commissioning so that the operation and maintenance staff use and consolidate their training by assisting the Contractor in the pre-commissioning and commissioning phases under the direction of the Contractor. The Contractor shall provide all the materials, training aids, venue and all facilities required for the training.

The training program will be divided into three groups:

1. PV plant design & Planning
2. PV plant & Substation O&M
3. I&C, SCADA related maintenance and troubleshooting

2.4.7.1 Program goals and objectives

The training program covers both training and qualification. The goal of the training and qualification program is to ensure that the PV Plant's personnel acquire and maintain the combination of knowledge and demonstrated skills to fulfill their responsibilities. Likewise, Employer will acquire the knowledge

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required to fulfill his responsibilities as Plant's owner during operation. This will reasonably assure that the PV Plant is operated safely and efficiently, while

also ensuring the long-term economic success of the Plant.

The site objectives required to attain these goals are as follows:

All designated personnel will participate in training to satisfy local law, permits, regulations, and any other training as assigned.

All designated personnel will participate in PV Plant familiarization training.

After training each employee will qualify by formal written program for the position for which each hold; and

Employees will be required to re-qualify for his or her position regularly to ensure maintenance of proficiency and knowledge of the PV Plant.

2.4.7.2 Staff responsibilities and training organization

All employees are responsible to participate in both formal and self paced training to achieve and maintain qualification for their assigned position. Maintaining an assigned level of qualification is a condition of continued employment.

The PV plant manager has the overall responsibility for ensuring that the PV plant personnel are adequately trained and fully qualified to perform their assigned duties.

The training supervisor is responsible for the day-to-day administration of the training and qualification plan. The training supervisor will work closely with all department managers to ensure effective program development.

The training will be held in English language. Documents and certificates will be in English only.

2.5 Requirements During O&M (Defect Liability Period)

2.5.1 General

Not Used.

2.5.2 O&M Requirements During the Defect Liability Period

Not Used.

2.6 Technical Documents and Information

2.6.1 Documentation to be submitted with Bid

The Bidder must complete all forms given in Section 4 - Bidding Forms and the Tables and Forms in Section 6 - Employer Requirements of the Bidding Document for the Plant. Some of them shall be submitted electronically as Excel-file. Technical data sheets should be supplemented by additional descriptions, explanations, drawings and all other information necessary for a clear understanding of the Bid to enable the Employer to undertake the necessary assessment, evaluation and verification of the technical and performance features of the Bidding Document.

2.6.2 Documentation to be Submitted after Award of Contract

The following describes the minimum scope of information, documents, drawings, etc. to be submitted by the Contractor to the Employer after award of contract during the design and engineering phase and during site construction of the Plant. The Employer reserves the right to request from Contractor such additional information, drawings, documents, etc. as may be reasonably required for proper understanding and definition of the design and engineering of the project.

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The Contractor shall provide soft copies and four (4) hard copies of all drawings and documentation to be submitted by him. For the as-built documentation a well-organized electronic file including an Excel based table of contents, two (2) copies (plus electronic copy) shall be provided. All information with respect to connection points and interfaces between the Plant and the 132kV evacuation line, and any other interface as well as for the entire Plant itself shall be included. The number of copies or the final content may be amended as may otherwise be required by the provisions of the Contract or as may otherwise be reasonably required by the Employer.

Monthly status reports shall be provided by no later than ten (10) days after the last day of each month. Any revision of the project implementation schedule shall not be delivered later than seven (7) days after such revision.

2.6.3 Documentation to be Submitted during Detail Design

The following documents shall be submitted as a minimum by the Contractor to the Employer within a maximum of six (6) months after the date of contract award:

- Drawings, technical information and documentation required for Employer to obtain permitting, certifying and/or licensing of the Plant
- general arrangement and layout drawings
- project documents (data sheets, specifications, drawings) for major systems and components including system description of the main systems
- underground / above ground ducts and cable arrangement drawings (civil and electrical)
- operation philosophy
- emergency response plan
- Health, Safety and Environmental (HSE) Plan
- cable size calculation according the IEC 60502-2 and IEC 60364-5-52
- soil resistivity measurement
- step and touch voltage calculation
- risk assessment for lightning according to the IEC 62305-2
- interface concept (concept and settings of protection equipment at the interface)
- detailed layout drawings including detailed roads design, slope, structure levels and level of terrain, arrangement of PV structures and foundations, water supply and drainage concept, and cable routing
- detailed drawings (architectural, reinforcement and steel structure drawings, workshop drawings) as a minimum for:
 - PV structures (including foundations)
 - Main control building structure drawing (including foundation)
 - Gatehouse structure drawing (including foundation)
 - Multipurpose Water Pump House (including foundation)
 - structures for surveillance and lighting equipment
 - cable channel and ducts
 - drainage channels and ducts

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- any other needed structure or baseplate
- Structural analyses as a minimum for:
 - PV structures including foundations
 - any other needed structure or baseplate
- The structural analysis shall include as a minimum the following information and specifications:
 - information of Codes and Standards
 - information of chosen design method and factors of safety
 - detailed description of structural model (dimensions, materials, definitions of connections and bearings)
 - specification of materials
 - definition of loads and load combinations
 - structural analysis including detailed report of the results (stress resultants, utilization, deflections, bearing loads)

Reports of the following site investigations:

- land survey of the total site
- soil investigation report including geotechnical recommendations for foundations and
- chemical soil analysis

Local pile tests for PV-structures foundations if micro pile foundations are planned:

- the pile tests shall be carried out in a professional manner and regarding the results of the soil investigation and structural analysis
- the tests shall be carried out in a sufficient number and test setup, the chosen pile specifications and dimensions shall meet the given requirements according structural analysis
- the tests shall be supervised by an expert and summarized in a report

For quality assurance and control, the following shall be delivered:

- specification and data sheets of all used electrical and mechanical components
- delivery notes of all used construction materials and components with detailed information and product specifications
- specification of chosen corrosion protection.

2.6.4 Documentation to be submitted during Site Construction

The following documents shall be submitted during site construction:

- It is to be noted that for all major works a method statement for the proposed works is to be included in the permit to work application along with the approved design review documentation at and specifics of the construction works and any associated risk evaluation for the relevant owner.
- The Contractor shall submit to the Employer drawings, diagrams, graphs, curves, calculations, schedules for information, review or approval as described in the Contract. The quality of all documents submitted shall conform to acceptable international practice.
- The Contractor shall provide the calibration certificates of all calibrated equipment to the Employer.



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- Monthly progress brief reports - by no later than one (1) week after the last day of each month including S-curves showing the work progress. The minimum information shall be:
 - ◇ Engineering activities
 - ◇ Component and material purchase and receipt status
 - ◇ Construction activities
 - ◇ HSE report including incidents and accidents
 - ◇ Personnel on site
 - ◇ Number of staff
 - ◇ Number of local staff
 - ◇ 4-week look ahead schedule
 - ◇ Recommendations for improvement
 - ◇ Project graphs
 - ◇ Layout drawings which shall show the work status
 - ◇ S-curves which shall show on a monthly base the status of the works (planned and actual as well as cumulated) for the PV Plant e.g. land preparation, security systems, piling, mounting structure, PV module installation, LV electrical works, MV electrical works, installation of transformer stations, building erection and interface works.

2.6.5 Documentation to be retained at site

Additional to the submission of the documentation as mentioned above the final documentation (including electronic files) has to be retained on site as listed in the following Clauses. The final documentation should be stored in a safe and lockable compartment.

2.6.5.1 Final Documentation

The Contractor shall deliver to the Employer the final documentation, both in digital and hard copies (2x). The final documentation for the PV Plant shall be prepared in accordance with the IEC 62446 standard "Minimum requirements for documenting, commissioning and inspecting grid connected PV systems"

The final documentation for the Plant shall comprise at least the following:

- the above mentioned documents listed in Section 6, Clause 2.6 as appropriate
- all As-built drawings
- O&M Manual with safety guidelines
- site safety procedures
- HSE procedure and plan
- key list and site access contacts
- components data sheets
- installation and O&M manuals from component manufacturers
- studies and tests (Pull out / extraction test, geological / geotechnical analysis, static calculation)
- Completion documents including but not limited to:
 - Data sheets and manuals of all components and equipment

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- Serial numbers of inverters, transformers, counters, sensors, etc.
- Module flash list (Excel files) with serial number and electrical values, and the exact location of the module within the PV plant
- Calibration protocols
- warranties of component suppliers
- ◇ Modules
- ◇ Mounting structure
- ◇ Galvanization and durability guarantee of fixed structure foundation
- ◇ Junction box
- ◇ Inverters
- ◇ Transformers
- ◇ LV and MV cables
- factory acceptance test reports
- acceptance protocols between Contractor and Subcontractors
- initial inventory list
- training program
- commissioning protocols

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