NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)
Project Management Directorate

BIDDING DOCUMENT
FOR

Procurement of Plant

For

Design, Engineering, Supply, Construction, Installation, Testing, Commissioning and Operation & Maintenance support of (AC) Solar PV Power Plants with Battery Energy Storage System at Humla, Mugu, Jumla and Dolpa districts of the Karnali Province of Nepal

Single-Stage: Two-Envelope
Bidding Procedure

Volume II

Issued on: 5th July 2023
Invitation for Bids No.:
OCB No.:
Employer: Nepal Electricity Authority
Country: Nepal

Employer's Requirements

This volume contains the specification, drawings, and supplementary information that describe the works to be procured.

Section 6 - Employer's Requirements

Table of Contents

ABBREVIATIONS

Abbreviation	Description
AC	Alternate Current
ACCB	AC Combiner Box
Al	Aluminium
BOS	Balance of System
c-Si	Crystalline Silicon
Cu	Copper
DC	Direct Current
DCCB	Direct Current Combiner Box
DCDB	Direct Current Distribution Box
GHI	Global Horizontal Irradiance
HDGI	Hot deep galvanised Iron
HDPE	High Density Poly Ethylene
i.e.	id est (that means)
IEC	International Electrotechnical Commission
IP##	Ingress Protection Code
MMS	Module Mounting Structure
MPPT	Maximum Power Point Tracker
NEA	Nepal Electricity Authority
O&M	Operation and Maintenance
PCMS	Power plant control and monitoring system
PGA	Peak ground acceleration
ppm	Parts per million
PV	Photovoltaic
PVC	Polyvinyl chloride
SLD	Single Line Diagram
SPBG	System performance bank guarantee
SPD	Surge Protection Device
SOC	State of Charge
STC	Standard Test Conditions
TDS	Total dissolved solids

WEIGHTS AND MEASURES

Units	Description
%	Percentage
^{o}	Degree
γ	Gamma (represents temperature co-efficient of PV modules)
^{o}C	Celsius
A	Ampere
ft	Feet

h	Hour
Hz	Hertz
I_{mp}	Current at maximum power
I_{sc}	Short Circuit currentγ
kg	Kilogram
Kg-f	Kilogram -force
km	Kilometre
km/hr	Kilometre per hour
kV	Kilovolt
kVA	Kilovolt Ampere
kW	Kilowatt
kWh	Kilowatt Hour
kW_p	Kilo Watt peak
m	Meter
m/s	Meter per second
m^2	Square meter
m^3	Cubic meter
mm	Millimetre
mm^2	Square millimetre
MW	Megawatt
MW_p	Megawatt peak
N	Newton
p	Pressure
T	Torque
V	Voltage
V_{mp}	Voltage at Maximum Power
V_{oc}	Open Circuit Voltage
W	Watt
W_p	Watt peak

1 Scope of Supply of Plant and Services

1.1 General

The scope of this bid is to design, supply, installation, testing, commissioning and operation and maintenance support for 3 years of grid-interactive smart systems consisting of solar photovoltaic (PV) power plants and battery energy storage systems (BESS). These plant facilities should be designed such that in the future, they can be integrated with existing and upcoming mini-hydropower plants at the four different locations in the Karnali Province of Nepal. The location name, GPS coordinates, the capacity of existing & proposed mini-hydropower plants and the capacity of proposed PV and BESS systems are presented in the table below.

Table 1: Locations for PV + BESS + hydropower plant

Site	Location Name	GPS Coordinates	Existing / Upcoming hydropower plant capacity (kW)	PV AC capacity (kW)	BESS usable nominal capacity (kWh)
Site 1	Chhayanath Rara Municipality, Mugu	29.5486N, 82.152178E	400	360*	2200
Site 2	Chandannath Municipality, Jumla	29.3048N, 82.1798E	998	950*	3800
Site 3	Thuli Bheri Municipality, Dolpa	28.9347N, 82.9072E & 28.934073 N, 82.906399 E	200	620*	2000
Site 4	Simikot Rural Municipality, Humla	29.9894N, 81.8436E	500	995*	3000

*These values are based on a preliminary remote assessment.

A snapshot of the google earth map showing the four sites is provided in Figure 1.

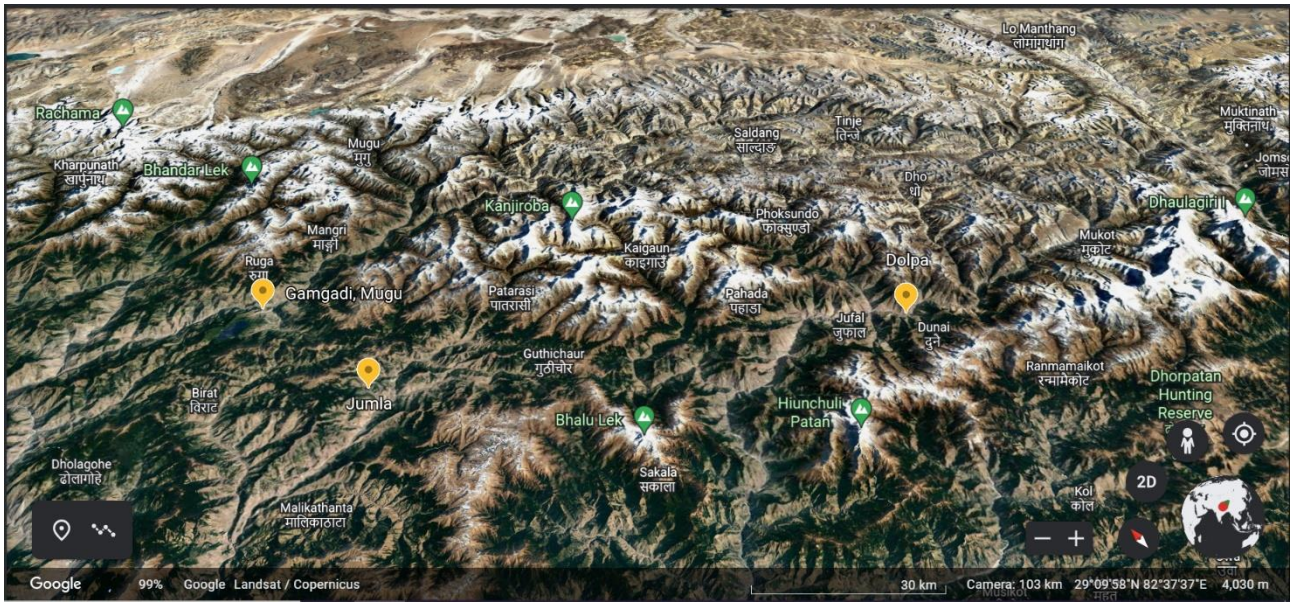


Figure 1: Google earth map showing the location of the four sites

1.2 Concept of operation

The PV-BESS systems will work under an AC-coupled (AC bus) configuration. The system shall be capable to operate as a standalone (off-grid) hybrid system and shall have provision to interconnect to the main grid at 11 kV through a bus coupler. The distribution feeder for loads operates at 11 kV. The solar PV + BESS plant must have the provision for future synchronization with upcoming and existing mini hydro plants at all 4 sites.

Hydropower generator forms the primary grid and provides all ancillary system functions. The power conditioning system of BESS (battery inverter) shall also be able to form the grid and should have the provision to synchronise with the hydropower generator in the future when the upcoming hydro plants in the areas are commissioned. Upon synchronization the PV plant will be seen as a negative load by the hydropower generators and thus it will inject its produced energy into the grid. The battery will be used to supply power in the morning and evening hours when hydropower will not be adequate and during the daytime it will be used to stabilize the grid when required (f/U) against sudden power fluctuation (from the load and/or the PV plant). The facilities must be designed to provision for these situations.

The Power Control and Monitoring System (PCMS) installed to manage the complete energy system should be capable of ensuring grid stability and restricting back feed to the hydropower generator by curtailing the output power of the PV inverters when needed (once hydropower generators are synchronized in the future). The controller should be able to constantly monitor the load demand, hydro generator available capacity & PV generation capacity and shall manage the system accordingly. A conceptual schematic block diagram for the proposed Solar PV + BESS system with a provision for future synchronization with hydro plants is presented in figure 2 below.

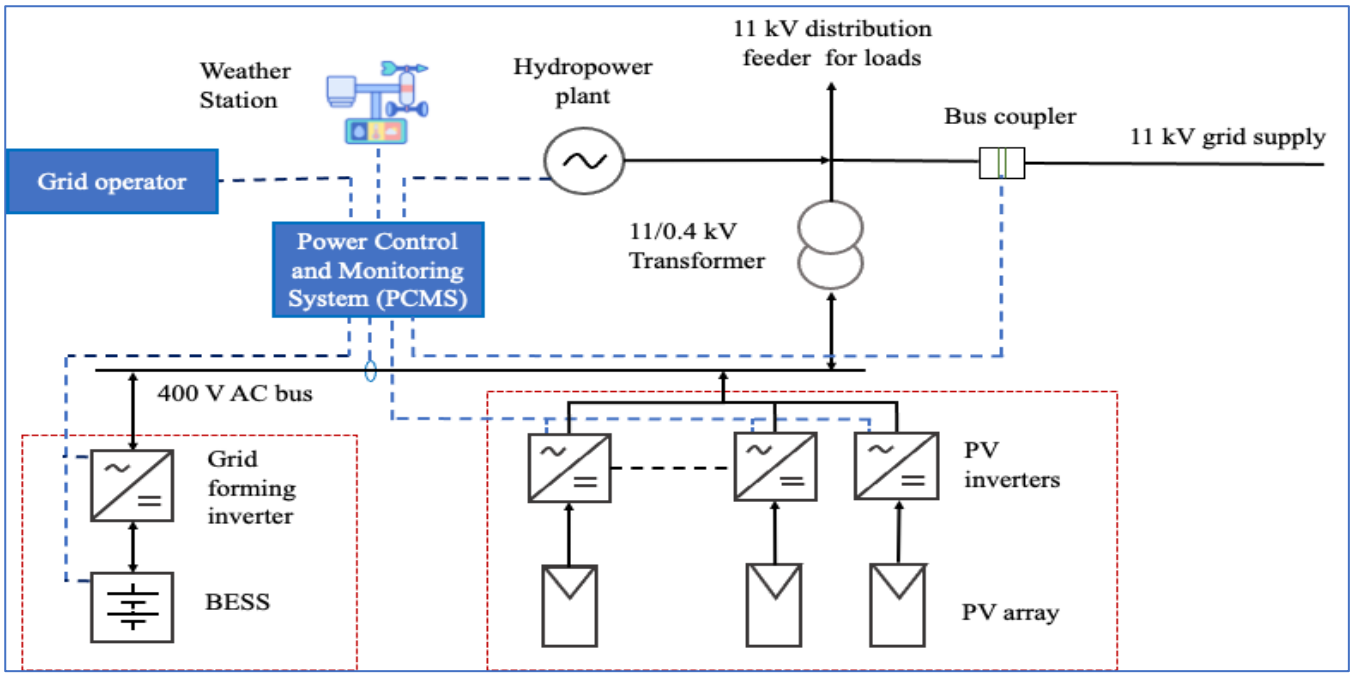


Figure 2: Conceptual schematic block diagram of proposed systems

The battery inverter must be capable to synchronize to other voltage sources in both cases: i) the battery inverter is online first and the other voltage source (hydro, grid, PV inverter, other battery inverters) must be synced to the battery inverter, ii) Other voltage sources are first online (hydro, other battery inverters), the battery inverter must be synchronized to them.
If the hydropower generators are static (isochronous) voltage sources without synchronization capability the synchronization must be done with an external synch check and breaker. The measurement of the required parameters of voltage, frequency etc. must be done fast and accurately enough to guarantee synchronization.

Upon synchronization, during the day, the PV and hydropower generator shall provide 100% of the load and charge the battery. If the battery is fully charged and the PV output power is higher than the loads in the system, the PV power shall be curtailed by frequency drop. In case, the system is interconnected to the grid, the excess power shall be fed to the grid and there shall be no curtailment of inverter power. On synchronization, the battery is expected to be discharged during the morning and evening hours when hydropower is not adequate. The battery shall discharge until the defined minimum State of Charge (SOC) is reached. Energy generation and load profile on a typical day has been presented in figure 3.

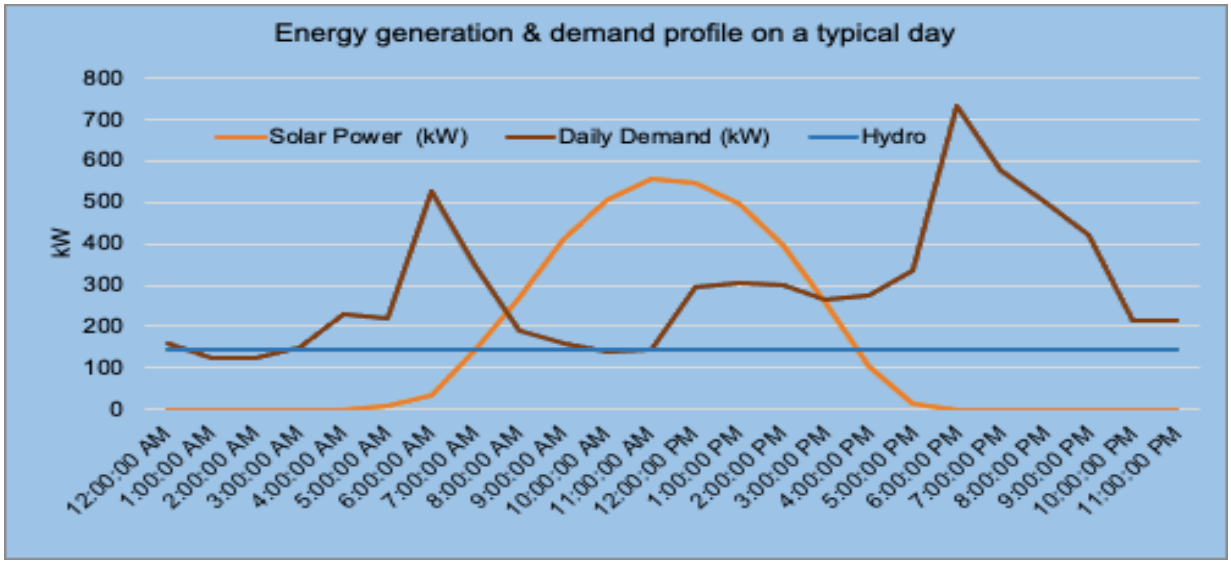


Figure 3: Energy generation and load profile on a typical day

When the system is not connected to the grid (off-grid) and the state of charge of the battery has reached its minimum level (SOC_{min}) and output from PV and/or PV and hydro is not adequate to supply power to the loads, there shall be partial load curtailment.

When the system is connected to the grid (on-grid) and the state of charge of the battery has reached its minimum level (SOC_{min}) and output from PV and/or PV and hydro is not adequate to supply power to the loads, the grid will charge the battery and supply power to the loads.

All communications between the power plant control and monitoring system (PCMS) and other devices will be performed using Fibre Optic Cable (FOC). An uninterrupted power system (UPS) with an additional battery is to be provided to supply backup power to PCMS for a minimum of 6 (six) hours continuous period.

1.3 Scope of work

The scope of supply, works and services shall cover, but not be limited to the following[1]:

- Assessment of the site and site characteristics including geotechnical studies and land survey.
- Development, detailed design as per site condition, engineering (including equipment specifications), permitting, procurement, manufacturing, factory testing, supply of all equipment (also including spare parts, consumables, special tools and handling equipment, etc.), **use all appropriate medium of transportation (air, land, etc) to transport to the site all goods in good condition so as to minimize transportation related damages (any damaged item is to be replaced by new item at no additional cost to the employer)**, storage on site, installation, construction, commissioning and performance testing of the systems[2]. Also, wherein road transport is not possible contractor shall quote including other means of transport to complete the supply of goods to the site.
- Provide Operational and Maintenance support during SLA period to ensure plant uptime, including making spares available and conducting repairs, as and when required, for a period of 3 years after issuance of operational acceptance certificate.
- Preparation of preventive and predictive maintenance guidelines.
- Preparation of comprehensive operation and troubleshooting manuals that details all components in a detailed layout and their expected performance, Dos and DONTs, PV module cleaning procedures, preventive and scheduled maintenance, details on warranties and how to recover if required, among others.
- Works and services related to preparation, civil, mechanical, electrical, instrumentation and control (I&C) and communication works including all required equipment for the execution of these works and services.
- Works related to improvement of road condition approaching to the solar plant site, civil work to prevent flash flood and erosion.
- Commission the plant and connect to the NEA system.
- Providing security at the site during construction as per insurance requirements and the security technical specifications of the Employer as per all applicable regulations, codes and standards.
- Providing training to personnel according to Employer´s requirements as specified in the bid document.
- Ensure occupational health, safety and environment for the construction and operation of the plant.

The Contractor[3] shall be responsible for the detailed design, engineering and construction of the overall system considering the site conditions, consisting of:

- PV system with PV modules, grid-tied inverters, mounting system, string combiner boxes, trenching, DC cabling, AC cabling, monitoring system and controller, UPS, communication cables, earthing and lightning protection, transformers, LV power interfacing panel, AC distri-

1 Considering that the grid is connected at low voltage, study and propose design to give best solution for the area
2 System refers to all the equipment mentioned in Volume III of the bid document
3 Winning bidder signing contract with the employer would be referred to as the contractor

bution boards, DC distribution boards, electricity meters, electrical connection to the existing system.

- Containerized Battery Storage System with batteries which are customized for each site, bi-directional battery inverters (grid forming inverters), battery racks, battery management and monitoring system & controller, UPS, DC cabling, AC cabling, communication cables, earthing, AC distribution boards, DC distribution boards, electricity meters and sensors, electrical connection to the existing system. Canopy must also be installed over the BESS containers. The containers must be thermally insulated and be equipped with adequate numbers of HVAC to maintain temperature at defined value by the battery manufacturer - IP-55 rating.
- The proposed power plant control and monitoring system (PCMS) must be capable of integrating and synchronising with the existing and upcoming hydropower generators at all 4 sites when required in the future.
- Security System (CCTV), Auxiliary Supply, Cleaning System, Switchgear, 11kV and 0.4kV Control Protection System, earthing system, water management system, yard lighting, boundary fencing, cable trenches, internal roads, water supply, meteorological station, and other items as mentioned in Volume III of the bid document.
- Boundary fencing, containerized control room cum office and any other structure required for the Solar PV + BESS plants.
- All containers must be customized for each site considering last mile connectivity to the sites. They must also be properly cladded with Aluminium Composite Panel, and a NEA logo shall be inserted.
- The provisions of Environment and Social Impact and Mitigation Plan (Including Undertaking from the contractor to dispose hazardous wastes to approved recyclers or return to the manufacturer) attached in Annexure II are to be performed by the contractor.

It is the sole responsibility of the contractor to design, engineer and plan all related work and installations, buildings, sub-systems, elements, system facilities, equipment, and services, including system hardware and software.

The Contractor shall collect and investigate all basic data which are needed for proper design, planning and engineering. This includes, but is not limited to:

- conduct site visits and basic evaluation needed for a proper design and engineering
- contour analysis, rainfall and weather study, water flow analysis and designing drainage and water flow diversion to avoid erosion and waterlogging.
- PV array layout planning based on contour profile without major earthwork and excavation.
- Investigation of geotechnical aspects and soil properties to finalise the design for building foundations, array mounting structures and foundations including technical study to understand possibility of landslide in the future.
- study of snowfall intensity and incorporate the same while designing the mounting structure and foundation.
- survey for suitability of proposed installation locations for equipment like batteries, inverters, controllers and other devices

- survey related to the grid connectivity which includes but is not limited to cable routes from the PV plant site to the hydro powerhouse, 11 kV main grid, 11 kV distribution feeder, condition assessment of connectivity at these locations

The Contractor is responsible for the supply, delivery, storage and handling of any equipment and material needed for the installation and implementation of services.

The Contractor shall provide complete engineering data, calculations, drawings, reports, and manuals for the Employer's review, approval and records.

The Contractor is responsible for the construction and implementation of the systems according to the design approved by the Employer. This includes, but is not limited to:

- PV system
- Power plant control and monitoring system (PCMS) and synchronisation panel must be inside the BESS container
- Containerized Battery energy storage system (BESS) housing with automatic temperature-controlled air-conditioning system for heating and cooling to maintain the inside temperature between 20-25 ^{o}C
- Switchgears and other major electrical equipment except for transformers, string inverters, combiner boxes and panels must be housed inside the container.
- Containerized control room cum office
- Masonry storeroom and shelter for security staff
- Security system (CCTV, surveillance system, etc)
- Other works (as per Volume III of the bidding document)

The contractor shall include in its scope all facilities and equipment necessary for the generation of power from the system and all works and services including workshop and store equipment, special tools and handling equipment, spare parts, consumables, etc. necessary for complete, safe, reliable, and efficient operation and preventive and corrective maintenance of the system.

The scope also includes works not explicitly stated in Section 6 or elsewhere in the bid document but reasonably required for the installation and operation of the systems according to good engineering practice. The contractor shall make provisions for power and water supply that may be required for the construction, installation, and commissioning of all plant facilities.

All deliveries and works shall meet or exceed applicable requirements set forth by the latest edition of the following international and national codes and standards. In addition, all local rules and regulations shall be strictly adhered to in all respects.

- ISO/IEC
- EN
- ISA (International Society of Automation)
- IEEE
- ITU (International Telecommunication Union)
- IS (Indian Standards) / BS (British Standards)

- National Building Code (NBC) of Nepal
- Guideline for developing utility-scale solar projects in Nepal
- NEA regulations and guidelines

No cost can be claimed for not being able to comply with required standards. Also, bidders are requested to thoroughly go through the bid document and send queries to make themselves clear on any standard related issues before bid submission.

Any minor electrical/communication equipment/items which are not mentioned in the biding documents but are required for the successful completion of the project shall be in the scope of contractor for which no extra payment will be made.
Any damages to the existing facilities of NEA, private property or other public property incurred by the Contractor during the transportation & construction process shall be borne by the contractor.

Contractor shall not leave any trenches or pits open for more than 24 hours from the time of excavation. The Contractor shall not start the work of excavation/drilling/boring without having consultation with the Employer.

Approved manufacturers shall manufacture new equipment, which shall be subject to the Employer's review and approval. Used, reconditioned, or salvaged equipment or material will not be allowed. All equipment used in connection with the project shall be as per approved design for the intended use of the equipment and subject to the inspection by the employer/or their representatives for major items. For minor items, employer upon submission of satisfactory technical specification to comply with acceptable standards shall waive the inspection. All major equipment shall be selected if they comply to qualification stated in Section III EQC of Volume I.

All parts of the plant shall be suitable in every aspect for continuous operation at maximum efficiency as well as part loads and minimum load, under consideration of the climatic conditions peculiar to the site and environmental restrictions.

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 project language is English. This applies also to any kind of documents, drawings, manuals, etc.

The individual sites are described in detail in Chapter 2, Site Specific Information. Any information which is not provided in Chapter 2, but needed for a proper design, engineering, implementation, O&M services and any related work shall be investigated by the contractor.

Detailed Survey of the site and design

The detailed survey for the plant with containerized BESS solution and associated civil works along with geo technical and land profiling shall be carried out by the contractor. With the detail survey, the contractor shall carry out the complete design of the plant and all the necessary civil structure and works to complete the specified scope of work. The Contractor shall submit the de-

tail design and survey report to the Employer for approval. With the approved design and drawings, the contractor shall prepare the revised Bill of Quantity and submit to the Employer for approval. The provisional quantity has been indicated in the Bill of Material/ schedule of prices.

Schedule of Quantities

The requirement of various items/equipment and civil works are indicated in Bid price Schedules. All equipment/items and civil works for which bill of quantity has been indicated in BPS (Bid Price Schedules) shall be payable on unit rate basis/quoted rate basis. Wherever the quantities of items/works are not indicated, the bidder is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective Bid price schedules. For contractor assessed items, bidders shall estimate the total requirement of the works and indicate lump sum price in relevant Bid price schedules. **Any material/works not specifically mentioned in the description in BPS but will be required to complete the work shall be deemed to be included in the quoted price.**

The detailed bill of quantities of the mandatory spares is as per BPS.

Bidder should include all such items in the bid proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and are required for successful commissioning of works shall be included in the bid price and shall be provided at no additional cost to the Employer.

Mandatory Spares

The Mandatory Spares shall be included in the bid proposal by the bidder. The prices of these spares shall be quoted by the Bidder in the relevant schedule of BPS and shall be considered for evaluation of bid. It shall not be binding on the Employer to procure all of these mandatory spares.
The bidder is clarified that no mandatory spares shall be used during the commissioning of the equipment. Any spares required for commissioning purpose shall be arranged by the Contractor. The unutilized spares if any brought for commissioning purpose shall be taken back by the contractor.

Specific Requirement

a. The bidder shall be responsible for safety of human and equipment during the working. It will be the responsibility of the Contractor to co-ordinate and obtain Electrical Inspector's clearance before commissioning. Any additional items, modification due to observation of such statutory authorities shall be provided by the Contractor at no extra cost to the Employer.
b. The Contractor shall arrange all as necessary supports, cranes, ladders, platforms etc. for transportation, installation, testing & commissioning of the system at their own cost. Further, all consumables, wastage and damages shall be to the account of the contractor.
c. Installation, testing and commissioning of Containerized BESS, Inverters, Solar PV Panels, Containerized switchgear and transformers shall be done by the contractors under the supervision of respective equipment manufacturers. Charges for the above

supervision shall be included by the bidder in the charges for the respective equipment in the BPS.

d. LIST OF PREFERRED MAKE/MANUFACTURER:

"It is preferred that the equipment be supplied from the manufacturers listed in ANNEXURE-I for mentioned equipment/items.

The bidders may offer equipment/brands other than those listed in ANNEXURE-I, that are better or equivalent with regard to quality and performance substantiated with appropriate documents.

Any deviation from the technical specifications that may arise during detail engineering shall be mutually agreed to complete the scope of project.

1.4 Social Safeguard and Environment Management Plan

The Contractor shall prepare Social Safeguard and Environment Management Plan to be implemented during execution of the Project. The following major activities shall be considered in addition to requirements of Annexure II:

Labour recruitment: The Contractor shall give preference to the use of local and regional labour provided that it is consistent with the requirement of good workmanship based on the need of the project.

Staff training and sensitization: At the beginning of works the Contractor shall organize training and awareness-raising workshops intended for their teams to improve their understanding to prevent or minimize the impact of their activities on the environmental and social aspects to promote good relations with the local people.

Among others topics addressed should also include the following:
Likely environmental impact of works, good practices, preventive and corrective measures to be adopted; Rules and procedures for waste management at construction sites; Safety risks associated with the works, and preventive attitude to adopt; First aid and what to do in case of accident; General standards concerning relations with the local people; Risks and prevention of sexually transmitted diseases. The training and awareness sessions should be organized whenever new workers are recruited. Feedback and training during the works and after the monitoring and control exercise, additional training and awareness activities may be necessary if it happens that the previous sessions had failed to achieve the desired effects.

Demarcation, signing and closing of worksites: Setting up warning signs at worksites to limit the access of persons, machinery and equipment into construction areas and confine the works related to the construction process to the allocated areas.

Access to private property: Contractor shall coordinate with the Employer for the access of private property, if required. Crossing of private property shall be subject to prior notification to the owners and conducted in such a manner as to minimize damage to crops or other property on the land.

Discovery of relics of historical and archaeological importance: In the unlikely event of discovery of historical relics, the works will be interrupted temporarily, and the discovery notified to the local authority responsible for cultural heritage in order to determine the appropriate course of action.

Restoration of sites: After the infrastructure has been put in place and the construction sites and equipment depots cleared, the sites should be rehabilitated without undue delay in the original condition or better, unless there are plans for future use requiring that such sites be left in their current state.

Storage and handling of hazardous substances: Hazardous substances such as oils, lubricants or other hazardous substances likely to contaminate surface or ground water and soil should be stored or handled in premises specially designed for this purpose, in order to protect the environ-

ment and human health. If the handling of oils and fuels is necessary, demarcated and water-proofed areas that may contain any spills must be provided.
Maintenance of equipment: Maintenance of equipment should be performed immediately at the work site as far as practicable.

Air quality and noise pollution: Care must be taken to ensure that all equipment, machinery and vehicles used for works and equipped with a combustion engine are in good working conditions to limit undesired emission of air pollutants and noise nuisance.

Construction works that could cause noise should be performed only outside normal rest hours near residential areas. When noisy works must be carried out close to schools or other noise-sensitive receptors, working hours should be so scheduled as to limit the nuisance caused.
It is forbidden to burn in the open any kind of household, toxic or hazardous waste, project induced waste and all types of scrap metal.

Restoration or damage compensation: If the works on private property cause damage to crops or other property, the Contractor must proceed with the repair of such damage or, where this solution is not sustainable, with the fair and timely compensation of the owners.

Management of material from digging trenches: Uncontaminated soil from excavations will be re-used to backfill the trenches. Any such soil that cannot be reused is deemed to be waste and must be conveyed to its final destination. Its uncontrolled spread is prohibited in places where it could cause damage. Minimum dust on ground policy is to be used to prevent dust associated pollution after the construction.

Public information on electrical hazards, behaviour and preventive measures: Before switching on the infrastructure installed as part of the project, the neighbouring populations should be informed in good time, through public meetings and/or distribution of information leaflets. The information provided to them should focus on the electrical hazards associated with the infrastructure and the behaviour that would allow them to avert such hazards. The population of these areas should be particularly targeted. Unanticipated Impacts identified during the construction should be mitigated in coordination with environmental and social monitors employed by Contractor, Consultant and Government separately.

NEA shall not be liable for any on site infrastructure. The contractors shall have their own onsite project management office and site warehouse for material storage with required security. For maintaining the hygiene, the contractor shall have adequate mobile toilets at multiple locations within the site. The minimum requirement for sanitation would be 1 portable toilet and urinal for every 40 construction workers. Also, contractor shall have adequate security guards before delivering any material on site.

Safety of Personnel

The maximum safety consistent with good practices in the case of work above ground must be afforded to personnel directly engaged under this contract. Reasonable measures shall be taken to afford adequate protection against material falling from a higher level onto personnel below.

1.5 Service Level Agreement (SLA)

Support services (including Maintenance) for 3 (three) years: After the successful commissioning of the entire project, the contractor shall provide the support services which shall include operation and maintenance support of the system installed under the project for a period of 3 (three) years from the date of issuance of operational acceptance of the project.

The Scope of Work shall include the power infrastructure operational support and maintenance to be provided by the Contractor in respect of the system supplied under this project for a period of three years, however during the execution of the infrastructure work it is expected that certain portion of the work if completed and put to service before the actual completion and commissioning of the entire project, then in that case also the support services including O&M shall be the responsibility of the contractor in accordance with this document, at no additional/ extra cost towards payment of support services (O&M) during this intervening period.

Single window service: The contractor shall provide a single window service to maintain SLA and in case of a joint bid only one organization shall be held responsible & accountable for the performance of the system as per defined SLA.

The contractor shall provide 24x7 support to NEA to comply with SLAs in case of any problem. It shall be the responsibility of Contractor to resolve any operation and maintenance related issues of the plant.

The Contractor is required to work with the Employer's technical personnel during whole SLA period. The Contractor shall support and build the capacities of local counterparts in the day-to-day management, operation and maintenance of the plant. Contractor shall conduct on the job training for these counterparts to ensure that they are able to maintain and operate the network in a stable and reliable manner in accordance with established Prudent Utility Practices. The Contractor is required to provide one field personnel per site for support service. Scope of work includes but not limited to:

i. Operation and Maintenance (including Preventive maintenance) of the Plant.
ii. Maintenance and rapid repair/replacement of defective equipment installed under the project.
iii. Predictive and preventive maintenance of the infrastructure.
iv. Support in inventory management.
v. Services to bring up any or all plants upon its failure and to restore the functioning of the same etc.
vi. Any future planning, augmentation and execution work for strengthening of the existing system shall be done by the contractor during the SLA period. Any material required for the above work shall be provided by the contractor on the same rates as per the award of the original contract.

The cost for the SLA shall be deemed to be included in the cost of equipment and installation services in BPS.

Guarantee/Warranty

The Contractor shall correct, without any delay and at its own expense, at any portion of the Work during defect liability period and extended defect liability period including any required correction in defective design, errors, omissions, or changes in documentation, or by providing a non-defective replacement within 3 days of notification of the problem.

The costs of replacement shall be at the Contractor's expense and shall include all shipping costs, duties, fees, and taxes, both to and from the Contractor/manufacturer's facility, and the appropriate technical advice and direction for removal of the defect and installation of the corrected Work including On-Site Services as required. In the event the System or any portion thereof, is down, the Contractor will begin the dispatch process of appropriate personnel as specified.

If the Contractor shall fail to correct any defect within a reasonable time, Employer shall have the right to employ others to do so. The contractor shall be liable for all costs and expenses thereby incurred by Employer. The Contractor shall provide to Employer, within 15 Days of the end of each calendar quarter, a list and description of all potential or actual problems.

Consultant for the Project

NEA shall appoint a consultant as the Post contract supervision consultant for this Project.

2 Site Specific information

2.1 General

The following section describes the site-specific information on account of location, surface and air connectivity, weather and climate, topography, geotechnical characteristics, load profile, grid infrastructure and availability of water.

The Bidder is responsible for its own investigations to establish sufficient and accurate information for the design of the plants. The Bidder shall visit the proposed sites and shall ascertain the nature and location thereof and all conditions which may affect the design/layout of the PV plant & BESS, point of connection to grid and hydropower plants, transportation and logistics and the impact of site parameters into the project costs.

Although care has been taken to ensure the accuracy, completeness and reliability of the information provided in the subsequent section for each site, the Employer assumes no responsibility thereof. The user of the information agrees that the information is subject to change. The Employer assumes no responsibility for the consequences of use of such information, nor for any infringement of third-party intellectual property rights which may result from its use. In no event shall the Employer be liable for any direct, indirect, special, or incidental damage resulting from, arising out of or in connection with the use of the information. Therefore, each Bidder is requested to make its own assessment of all the information required for the purpose of establishment of the system. Neither the Employer nor any representative or advisor is responsible for the accuracy or completeness of any such information.

2.2 MUGU

2.2.1 Location details

The general data of the site is shown in the following table 2 below:

Table 2: General information of Gamgadi site

Sl. No.	Site parameters	Details
1	Site Name	Gamgadi NEA office
2	GPS Coordinates	29.5486N, 82.152178E
3	Elevation	2175 m
4	Number of consumers	8000 (projected)
5	Nearest Town	Gamgadi Town
6	Nearest metalled road	Kalikot/Jumla to Gamgadi - part of Karnali Highway (H13)

Sl. No.	Site parameters	Details
7	Connecting road	From Jumla to Gamgadi (main highway road) with bearing capacity of about 12 - 15 Mt
8	Nearest Airport	Talcha Airport is approx. 7 km away from the proposed sites

Figure 4 below shows an image of the site on Google Maps and the distance to the nearest airport

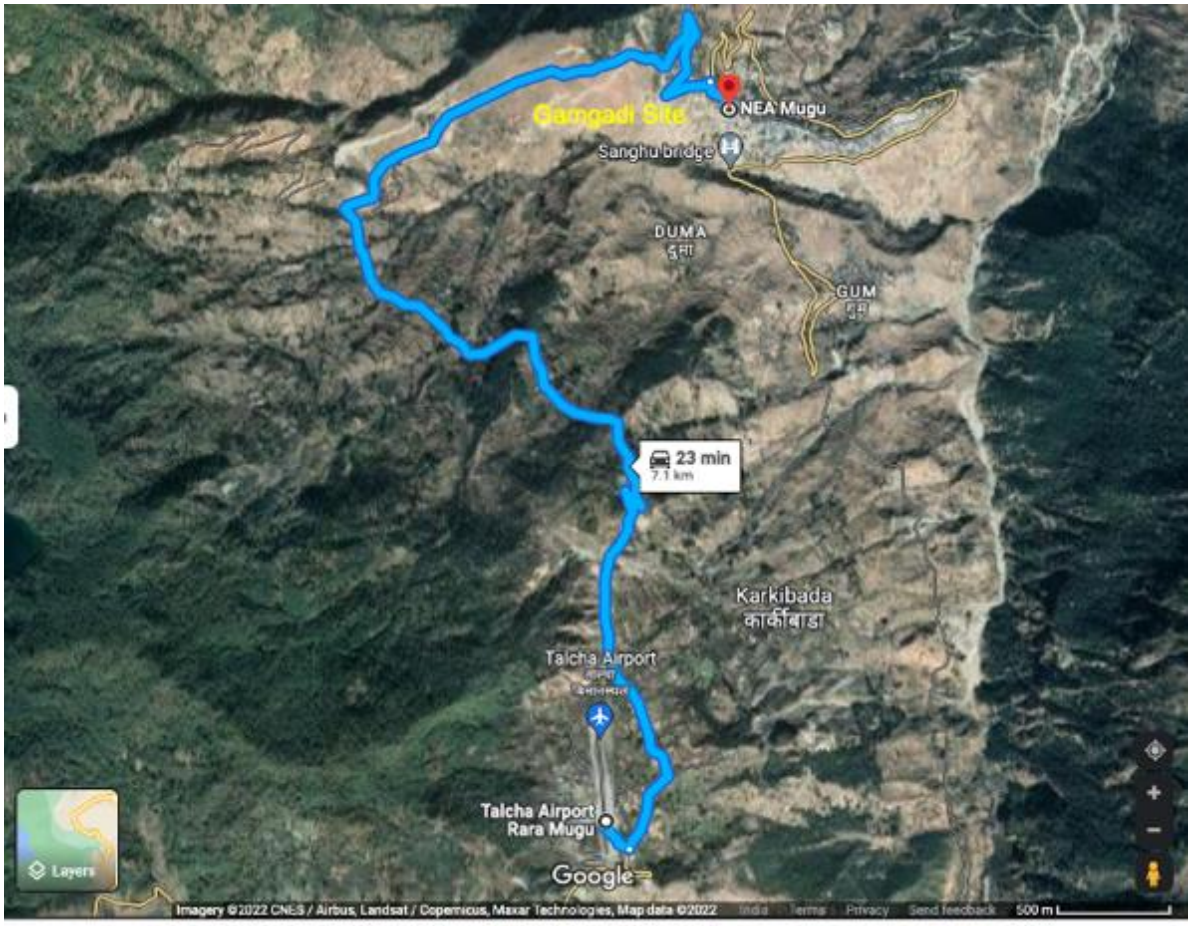


Figure 4: Gamgadi site shown in google earth map and the distance to the nearest airport

2.2.2 Surface and air connectivity

The site is connected by a main highway from Jumla to Gamgadi with a bearing capacity of about 12 metric ton. Kalikot/Jumla to Gamgadi road is a part of Karnali Highway (H13). Talcha Airport is approximately 7 km away from the proposed site. The contractor shall assess the last mile connectivity to the site and make provisions for approach to the site if required.

2.2.3 Weather and climate

2.2.3.1 *Solar radiation*

The average annual solar radiation at the horizontal surface is 5.29 kWh/m^2/day with a minimum value of 3.71 kWh/m^2/day in the month of January and a maximum value of 6.84 kWh/m^2/day during May. The average annual solar radiation at the tilted surface facing the equator is 5.43 kWh/m^2/day with a minimum value of 4.48 kWh/m^2/day in the month of July and a maximum value

of 6.22 kWh/m^2/day during April. Monthly average solar radiation (kWh/m^2/day) profile is presented in the figure 5 below.

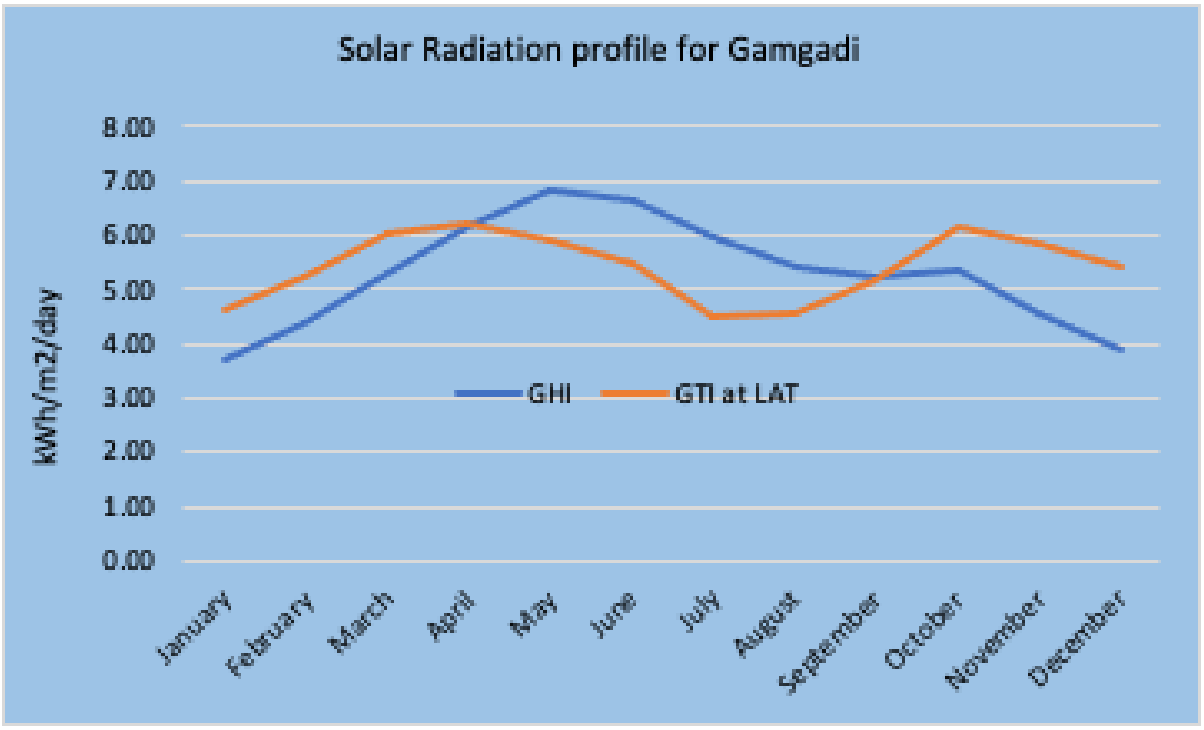


Figure 5: Solar radiation profile for Gamgadi site
(Source: https://power.larc.nasa.gov/data-access-viewer/)

2.2.3.2 *Ambient temperature*

The site experiences sub-zero ambient temperature for six to eight months in a year (January to May and October to December). The monthly maximum and minimum temperature profile are presented in figure 6 below.

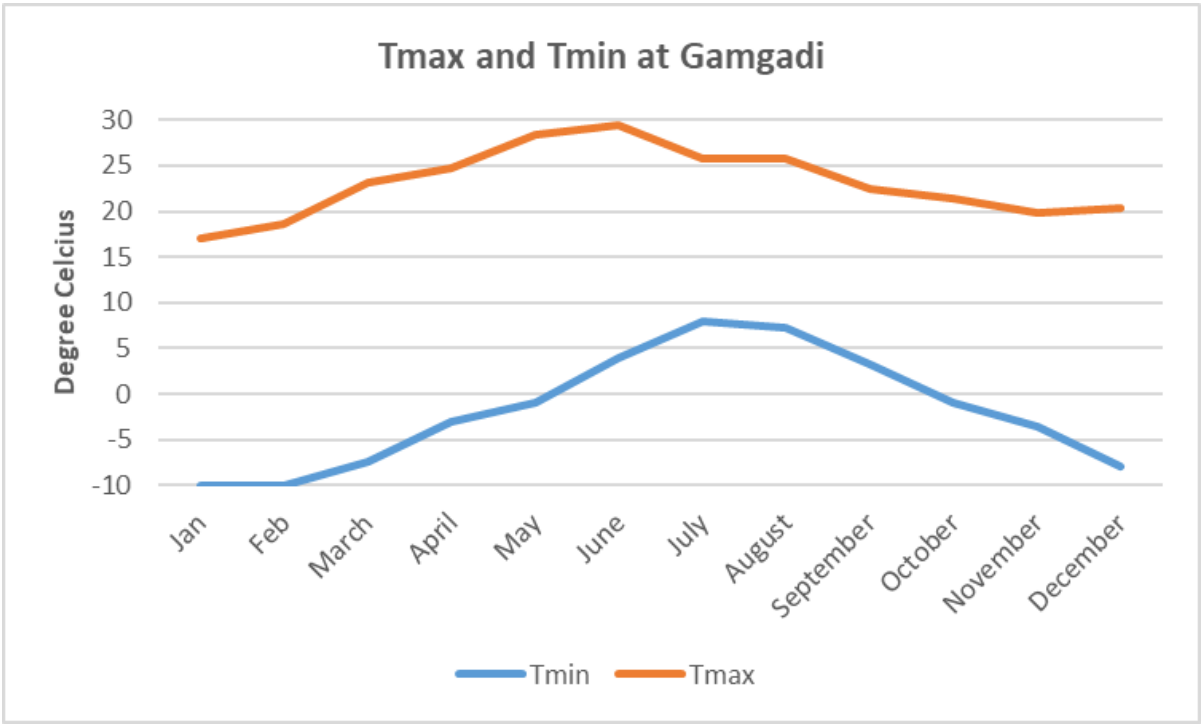


Figure 6: Maximum and minimum ambient temperature at Gamgadi site (Source: NASA)
(Source: https://power.larc.nasa.gov/data-access-viewer/)

Table 3: Solar and temperature data

Months	GHI (kWh/m^2/day)	GTI at LAT (kWh/m^2/day)	T_{max}	T_{min}
January	3.71	4.65	17.08	-10
February	4.36	5.23	18.58	-10
March	5.27	6.03	23.06	-7.5
April	6.18	6.22	24.79	-3
May	6.84	5.93	28.34	-1
June	6.64	5.49	29.39	3.93
July	6.00	4.48	25.79	7.97
August	5.44	4.56	25.73	7.18
September	5.21	5.16	22.47	3.24
October	5.35	6.16	21.33	-1
November	4.59	5.86	19.77	-3.5
December	3.90	5.44	20.3	-8
Annual Average	5.29	5.43	23.05	-1.86

2.2.3.3 *Basic wind speed*

The basic wind speed for higher hills is 55 m/s (~ 200 km /hour) as per NBC 104: 1994. The site at Gamgadi may experience high wind speeds.

2.2.3.4 *Snowfall and Rainfall*

The minimum ambient temperature of the site from November to April is (-)3^{o}C to (-)10^{o}C. The area around the site receives up to 1 to 2 ft of snowfall for about 10 – 15 days in a year.
Average rainfall received at the site is about 39mm and historically it has varied between 12mm to 70mm. The data for over 50 years is presented in the figure below.

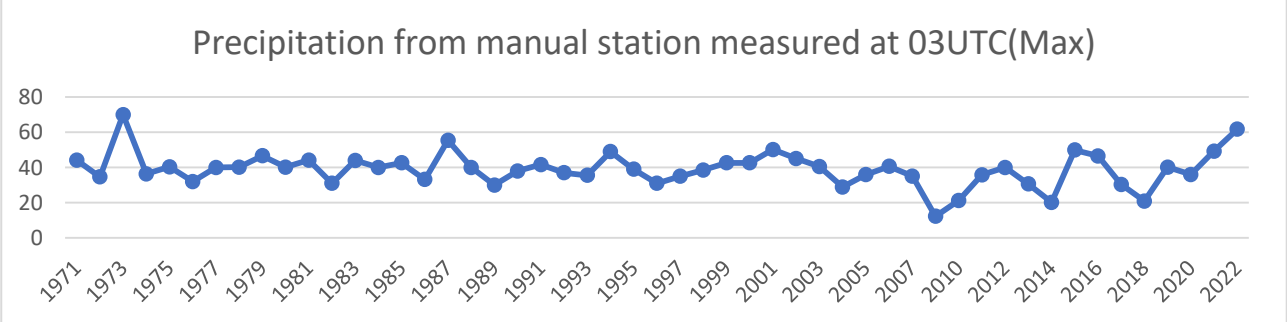


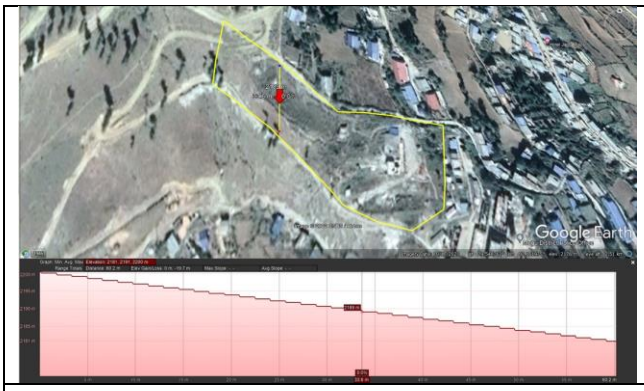
Figure: Rainfall data from 1970 to 2021

2.2.4 Topography and slope

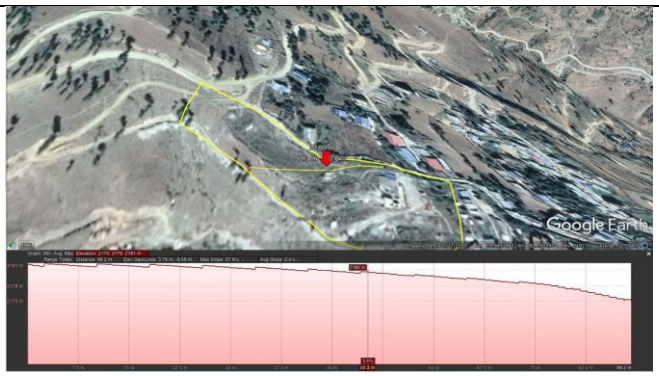
The land parcel can accommodate about 400 kW (AC) modules. BESS can be established in eastern part of the land parcel. The land parcel has a slope towards the south with variation between 10^o to 17^o. The slope in the west to the east direction is between 3^o to 6^o. Slope analysis and contour map of the site are presented in the figures below.

Rainwater will flow from the north to south which will be equally distributed. There is no major water flow passing through the site. To avoid soil erosion rainwater must be diverted/channelised at the north, west and east side of the land parcels.

Figure 7: Land parcel marked for installation of the solar power plant at Gamgadi site

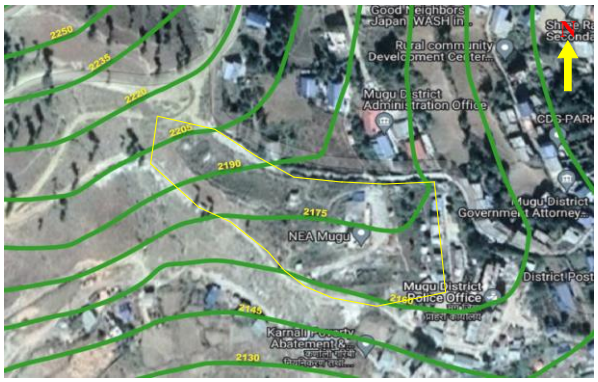


North-south slope of land parcel 10^o - 17^o



East - west slope of land parcel 3^o - 6^o

Figure 8: Slope analysis of two land parcel at Gamgadi site



Contour map of Gamgadi site

Waterflow map of Gamgadi site

PV array layout in land parcel

Figure 9: Contour map, Waterflow map and indicative PV array layout at Gamgadi site

2.2.5 Geotechnical information

Sedimentary to low grade metamorphic rock like slate, dolomites/ limestone, quartzite rocks exposed in the nearby areas observed. (1m - 5m alluvial deposit with coarse gravel and sand followed by rock stretch (gneiss, quartzite, dolomite, phyllite). Seismic zoning factor as per NBC 105:2020 PGA =0.25g. The bedrock is susceptible to weathering and thus renders the slope slightly unstable and prone to landslides. As a result, the site might need to be protected against risk of landslides by creating benches and retention walls for slope stability.

2.2.6 Load profile

The approximate number of households that will be connected to the PV-BESS system will be 8000 with an evening peak demand of 1000 kW and a morning peak demand of about 700 kW. The existing 400 kW hydropower plant is working at 80% efficiency. A typical daily load profile and estimated generation profile of PV and hydropower plants are presented in figure 10.

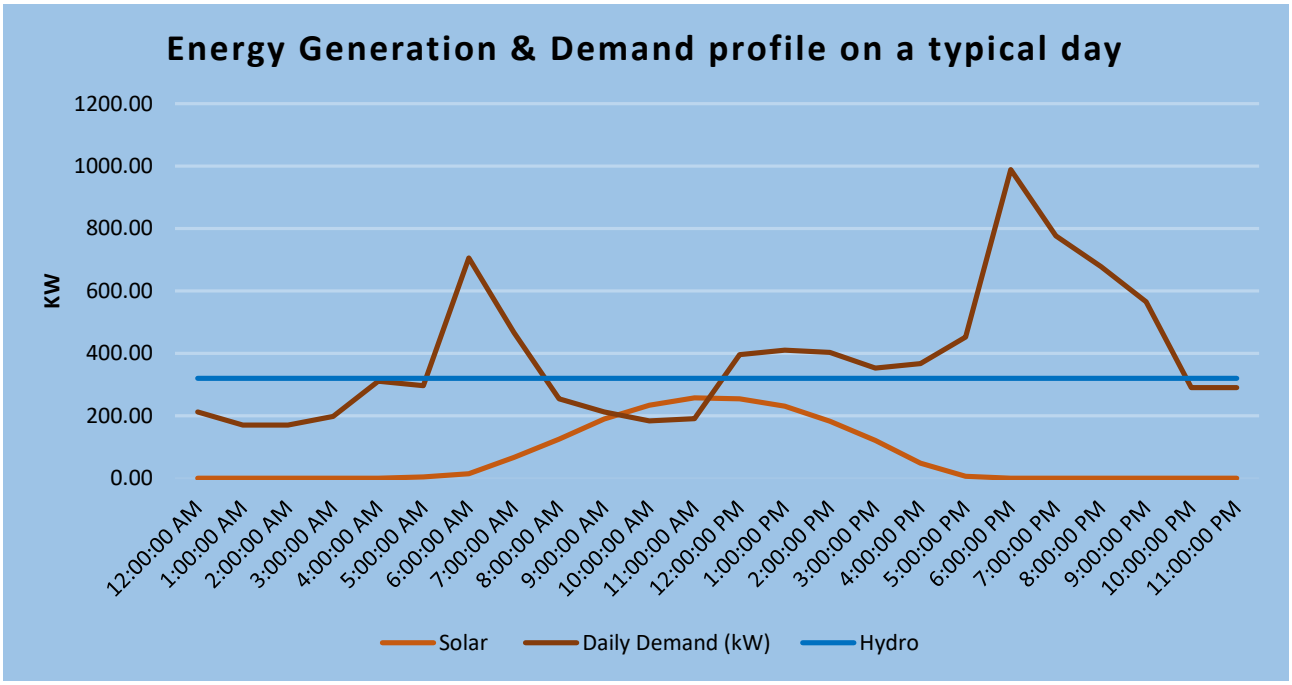


Figure 10: Typical daily load and generation profile Gamgadi site (Source: NEA)

2.2.7 Grid Infrastructure

2.2.7.1 *Point of interconnection is to be made upto 11kV pole in the vicinity of the land parcel at each site. Connection beyond that point is the scope of the employer.*

2.2.8 Availability of power at the site

Electricity is available at the site from Gamgadi 400 kW hydropower plant. Contractor is expected to have a backup power required for their construction related purpose.

2.2.9 Availability of water and quality of water

Mugu Karnali river is 2 km away from the site in Northeast direction. Spring water is available approximately 300 m in the south direction from the site. Spring water is clean with mild hardness. The contractor shall make provision for supply of water to the site if required for installation and construction activities.

2.2.10 Dust Pollution

The site is located on a dry hill with high wind speeds, therefore prone to thick dust. Therefore, dust accumulation on panels and frequent cleaning would be required.

2.2.11 Far Shading

The site has a high hill to its west, which hides the sun during the evening hours. This leads to the site being under shade during late evening hours, usually post 5-6pm.

2.2.12 Site clearance requirement

The block requires to be cleared of materials, shrubs, rocks, rubble etc. The site needs to be levelled as it has several undulations. There is a small shed inside the block which will also has to be dismantled according to the inputs from the Employer. The site clearance & dismantling shall be conducted with proper accounting in the presence of representatives of concerned office of NEA and the materials shall be returned to designated NEA stores at the expense of the contractor. Site pictures are attached below.

Gamgadi Site

Gamgadi Site

Shed to be demolished **Gamgadi Site**

2.3 JUMLA

2.3.1 Location details

The general data of the site is shown in the following table 4 below:

Table 4: General information of Jumla site

Sl. No.	Site parameters	Details
1	Site Name	Jumla NEA powerhouse area
2	GPS Coordinates	29.3048N, 82.1798E
3	Elevation	2497 m
4	Number of consumers	10000 (projected)
5	Nearest Town	Jumla Town
6	Nearest metalled road	From Manma (Kalikot district) to Jumla town (Jumla district) - part of Karnali Highway (H13)
7	Connecting road	From Manma (Kalikot district) to Jumla town (Jumla district) (84 km)- Road of 4.5 m width with bearing capacity of about 12 metric ton
8	Nearest Airport	Jumla Airport is 4.6 km away from the proposed sites

Figure 11 below shows an image of the site on Google Maps and the distance to the nearest airport.

Figure 11: Jumla site shown in google map and distance to the nearest airport

2.3.2 Surface and air connectivity

From Manma (Kalikot district) to Jumla town (Jumla district) - part of Karnali Highway (H13). From Manma (Kalikot district) to Jumla town (Jumla district) (84 km) - Road of 4.5 m width with bearing capacity of about 12 metric ton.
Jumla Airport is about 5 kms away from the proposed site. The contractor shall assess the last mile connectivity to the site and make provisions for approach to the site if required.

2.3.3 Weather and climate

2.3.3.1 *Solar radiation*

The average annual solar radiation at the horizontal surface is 5.03 kWh/m^2/day with a minimum value of 3.58 kWh/m^2/day in the month of January and a maximum value of 6.38 kWh/m^2/day during May. The average annual solar radiation at the tilted surface facing the equator is 5.43 kWh/m^2/day with a minimum value of 4.48 kWh/m^2/day in the month of July and a maximum value of 6.22 kWh/m^2/day during April. The monthly average solar radiation (kWh/m^2/day) profile is presented in figure 12 below.

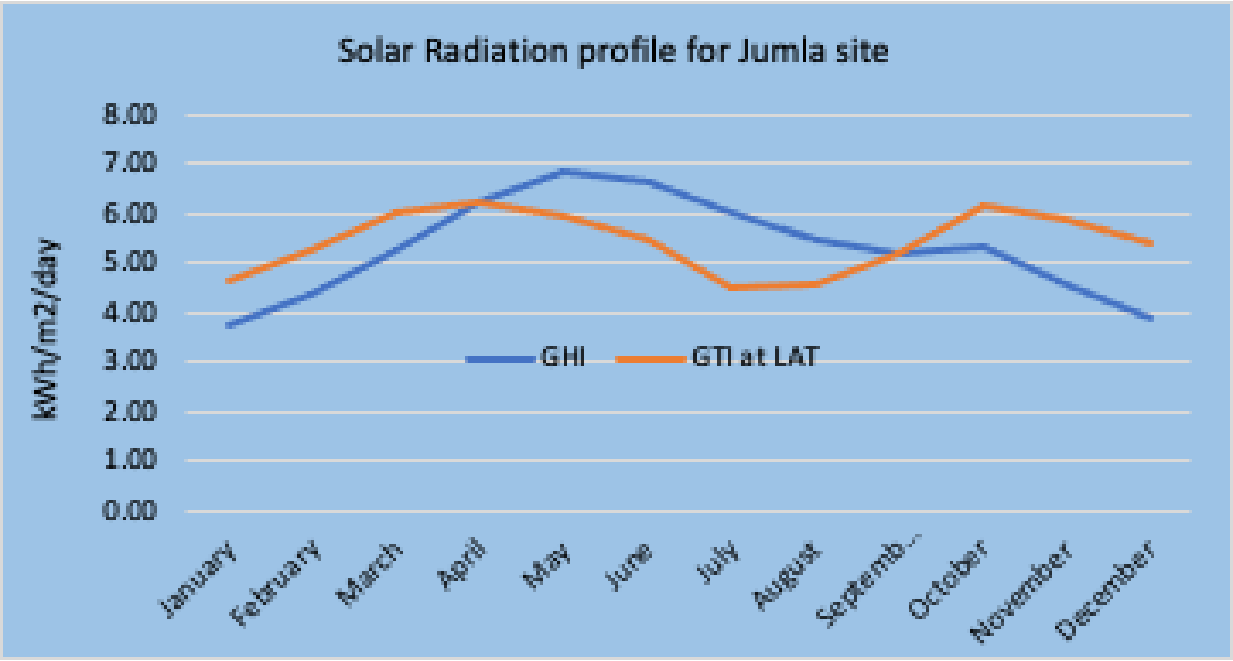


Figure 12: Solar radiation profile for Jumla site
(Source: https://power.larc.nasa.gov/data-access-viewer/)

2.3.3.2 *Ambient temperature*

The site experiences sub-zero ambient temperature for six - eight months in a year (January to May and October to December). The monthly maximum and minimum temperature profile are presented in figure 13 below.

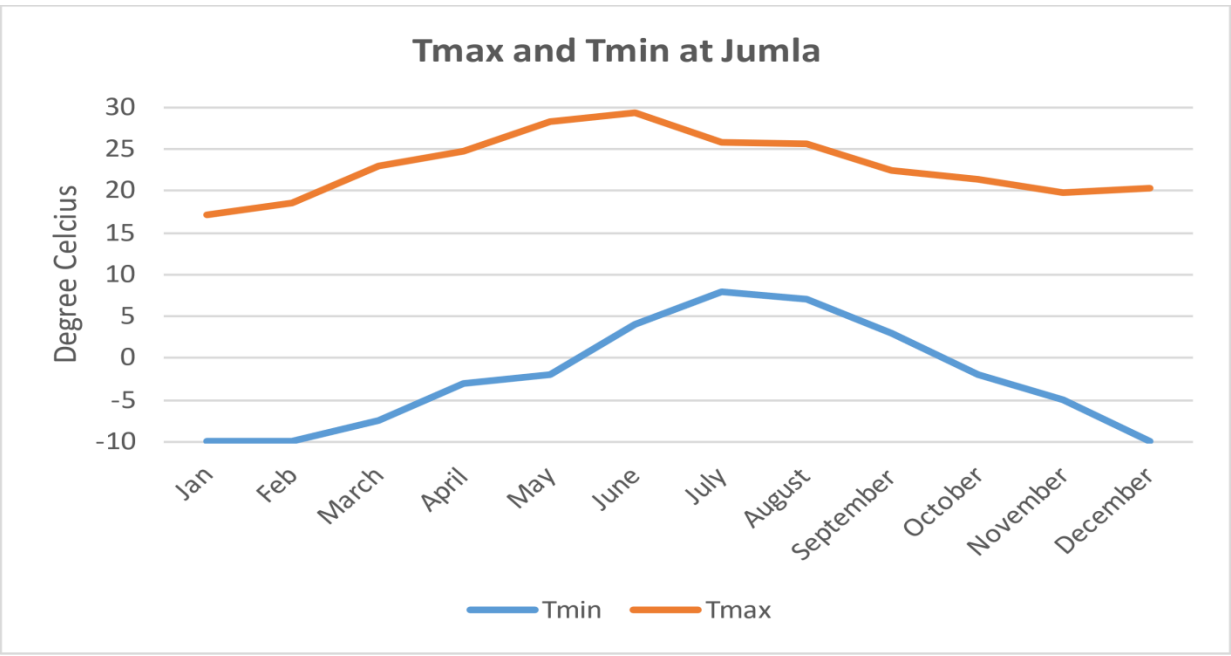


Figure 13: Maximum and minimum ambient temperature at Jumla site
(Source: https://power.larc.nasa.gov/data-access-viewer/)

Table 5: Solar and temperature data

Months	GHI (kWh/m^2/day)	GTI at LAT (kWh/m^2/day)	T_{max}	T_{min}
January	3.58	4.64	17.08	-10
February	4.43	5.22	18.58	-10
March	5.59	6.02	23.06	-7.5
April	6.25	6.22	24.79	-3
May	6.38	5.93	28.34	-2
June	6.06	5.48	29.39	4
July	4.83	4.48	25.79	8
August	4.76	4.56	25.73	7
September	5.02	5.15	22.47	3
October	5.23	6.15	21.33	-2
November	4.43	5.84	19.77	-5
December	3.85	5.42	20.3	-10
Annual Average	5.03	5.43	23.05	-2.3

2.3.3.3 *Basic wind speed*

The basic wind speed for higher hills is 55 m/s (~ 200 km /hour) as per NBC 104: 1994

2.3.3.4 *Snowfall and Rainfall*

The minimum ambient temperature of the site from November to April is (-)3^{o}C to (-) 10^{o}C. The area around the site receives up to 1.5 to 2 ft of snowfall for about 10 – 15 days in a year.
Average rainfall received at the site is about 50mm and historically it has varied between 23mm to 200mm. The data for over 60 years is presented in the figure below.

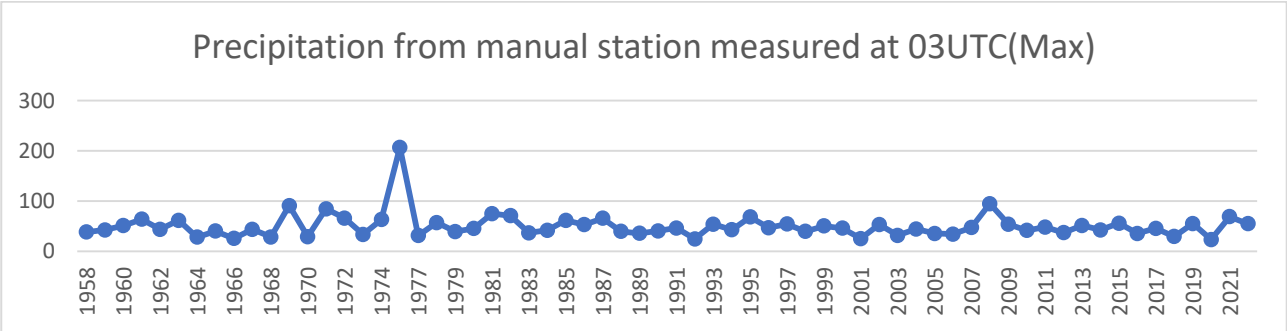


Figure: Precipitation data from 1958 to 2021

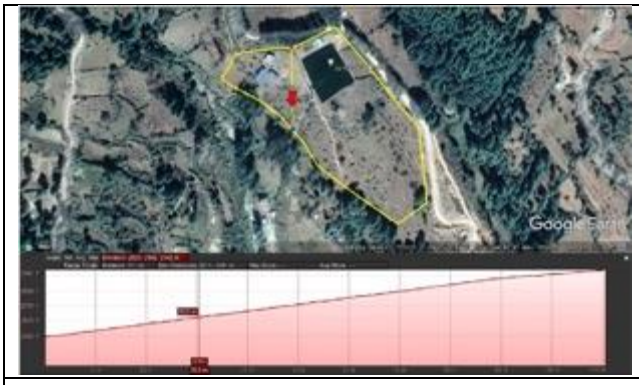
2.3.4 Topography and slope

The identified land parcel can accommodate about 950 kW (AC) PV arrays. BESS and control room can be established in the north part of the land. The land parcel has a slope towards the south with variation between 5^o to 10^o. The slope in the east to the west direction is between 1^o to 2^o in the north part and 4^o to 5^o in the south part. Slope analysis and contour map of the site are presented in the figures below.

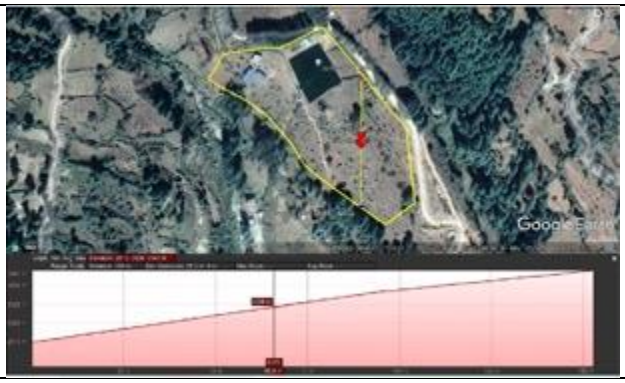
The site is divided into two parts, a flat plateau top around the reservoir and a gently sloping block of land leading up to the plateau top. The gently sloping block was observed to have a slope of about 5 – 10 degrees. The land doesn't have much vegetation cover that would be needed to be removed. The land has minor undulations which can be addressed with little earthwork.
The plateau top around the reservoir is nearly flat and doesn't require much civil work at all.

Rainwater will flow from north to south and northeast to southwest and the site appears to be not affected by heavy water flow. To avoid soil erosion rainwater must be diverted/channelised at the north and northeast side of the land parcels.

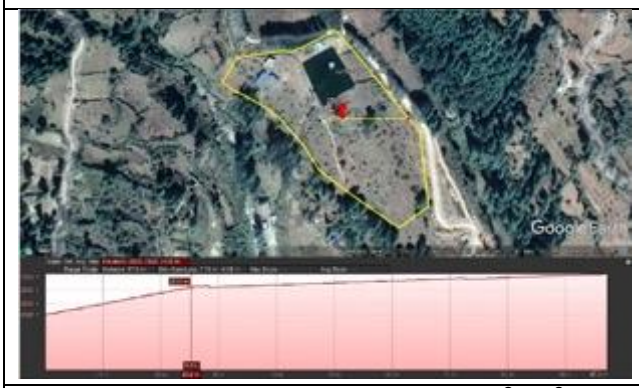
Figure 14: Land parcel marked for installation of the solar power plant at Jumla site



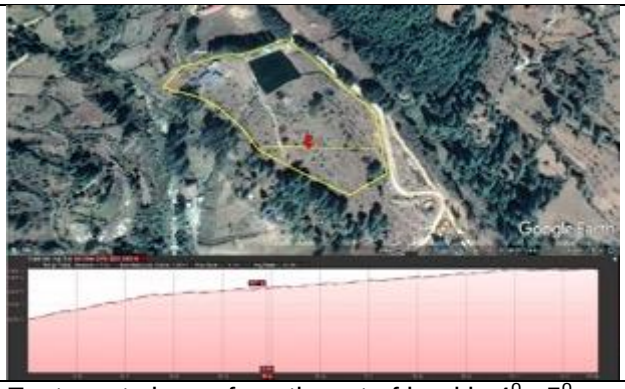
North-south slope of the west part of land ~10°



North-south slope of the east part of land ~10°

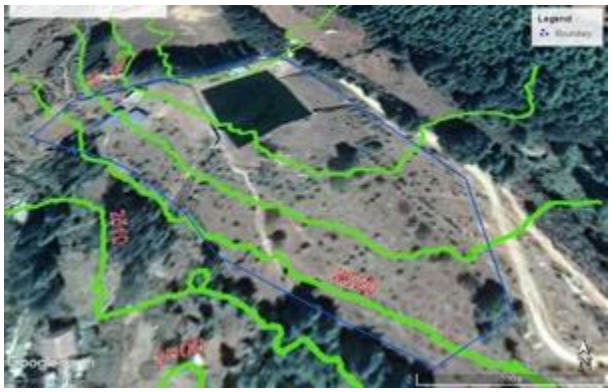


East-west slope of north part of land 1° - 2°



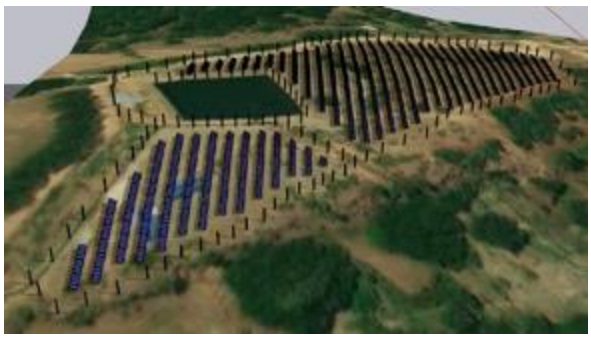
East-west slope of south part of land is 4° - 5°

Figure 15: Slope analysis of two land parcel at Jumla site

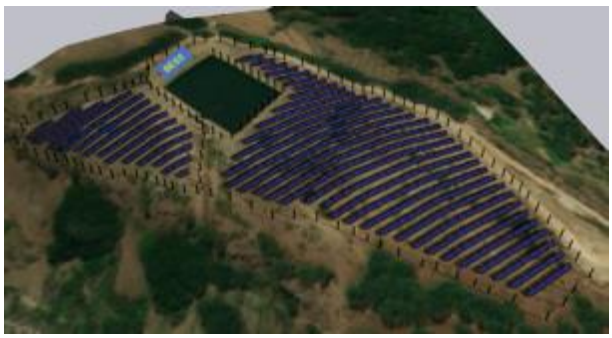


Contour map of Jumla site and surrounding

Waterflow map of Jumla site and surrounding



PV array layout in land parcel 1



PV array layout and possible BESS location

Figure 16: Contour map, Waterflow map and indicative PV array layout at Jumla site

2.3.5 Geotechnical information

High grade metamorphic rocks like slate genesis rocks exposed, silty soil with small pebbles seen on ground surface. (1m - 3m alluvial deposit with coarse gravel and sand followed by rock stretch (gneiss, quartzite, dolomite, phyllite). Seismic zoning factor as per NBC 105:2020 PGA =0.3g.
The site sits atop a hard bedrock. The rocks exposed in the area seem to be quartzite, chert and minor phyllites4. It seems stable and poses very little risk of landslides.

2.3.6 Load profile

The approximate number of households that will be connected to the PV-BESS system will be 10000 with an evening peak demand of 2200 kW and a morning peak demand of about 1600 kW. The existing 998 kW hydropower plant is working at 80% efficiency. A typical daily load profile and estimated generation profile of PV and hydropower plants are presented in figure 17.

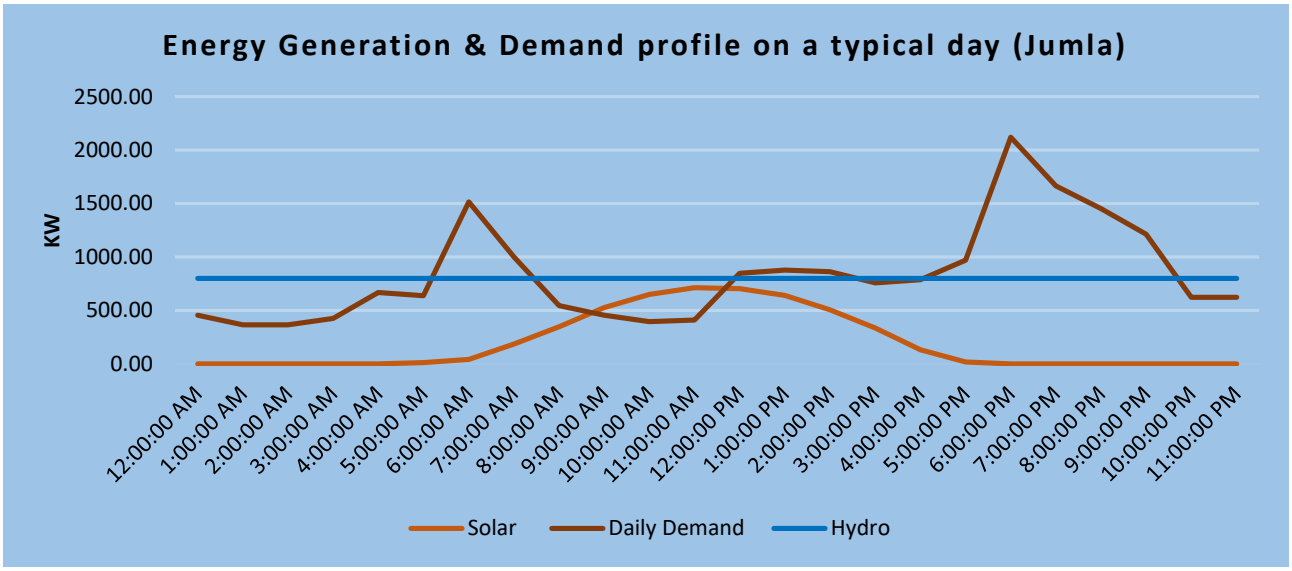


Figure 17: Typical daily load and generation profile Jumla site

2.3.7 Grid Infrastructure

2.3.7.1 *Point of interconnection is to be made upto 11kV pole in the vicinity of the land parcel at each site. Connection beyond that point is the scope of the employer.*

2.3.8 Availability of power at the site

33/11 kV Jumla substation under construction & Jumla small hydropower (998 kW). Contractor is expected to have a backup power required for their construction related purpose.

[4] Geology of Western Nepal and a comparison with Kumaun India, Shiraishi and Hayashi, 1984.

2.3.9 Availability of water and quality of water

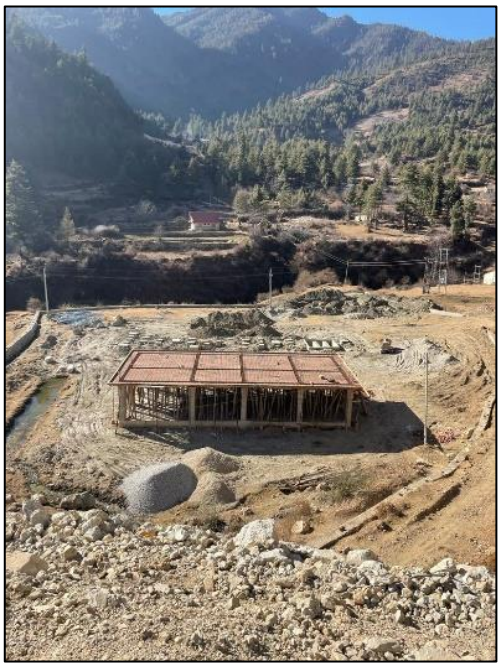
River is nearby (approx. 100 m away) from the site. River water is clean with mild hardness. The contractor shall make provision for supply of water to the site if required for installation and construction activities.

2.3.10 Far shading

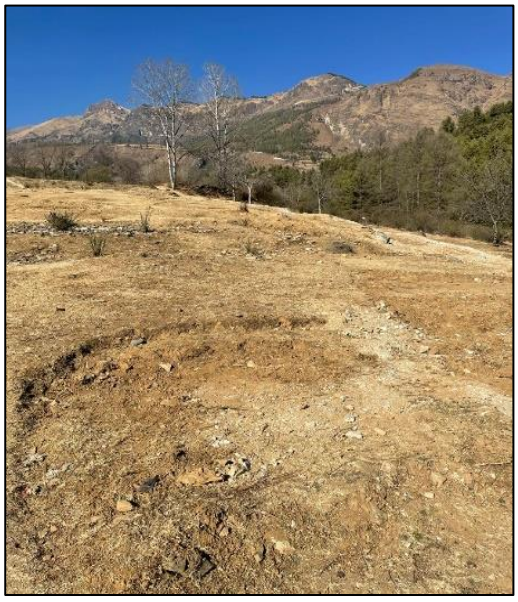
The site is south facing and doesn't have much far shading effect.

2.3.11 Site Photographs

Jumla Site – Gentle Slope



Upcoming Sub Station near Jumla Site



Jumla Site – Gentle Slope

Jumla Site – Flat Land near reservoir

2.3.12 Site clearance requirement

The block requires to be cleared of materials, shrubs, rocks, rubble etc. The site needs to be levelled as it has several undulations. There is a small shed inside the block which may also has to be dismantled according to the inputs from the Employer. The site clearance & dismantling shall be conducted with proper accounting in the presence of representatives of concerned office of NEA and the materials shall be returned to designated NEA stores at the expense of the contractor. Site pictures are attached below.

2.4 DOLPA

2.4.1 Location details

The general data of the site is shown in the following table 4 below:

Table 4: General information of Dolpa site

Sl. No.	Site parameters	Details
1	Site Name	Dunai, Dolpa
2	GPS Coordinates	28.9347N,82.9072E & 28.934073 N, 82.906399 E
3	Elevation	2177 m
4	Number of consumers	3000 (projected)
5	Nearest Town	Dunai town
6	Nearest metalled road	From Jajarkot to Dunai town (Dolpa district)
7	Connecting road	From Jajarkot to Dunai town (Dolpa district) (118 km)-Road of 4.5 m width with bearing capacity of about 12 metric ton
8	Nearest Airport	Dolpa Airport is 14.75 km away from the proposed site

Figure 18 below shows an image of the site on Google Maps and the distance to the nearest airport.

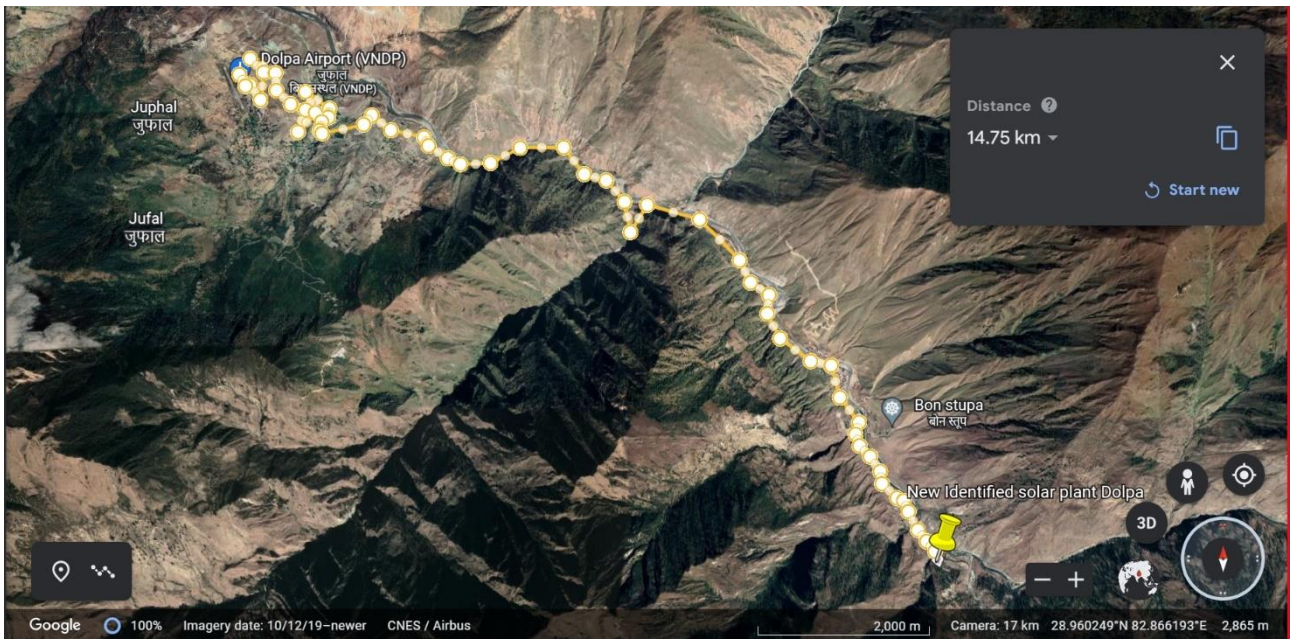


Figure 18: Dolpa site shown in google map and distance to the nearest airport

2.4.2 Surface and air connectivity

From Jajarkot district to Dunai town (Dolpa district). From Jajarkot district to Dunai town (Dolpa district) (118 km) - Road of 4.5 m width with bearing capacity of about 12 metric ton.
Dolpa Airport is about 15 kms away from the proposed site. The contractor shall assess the last mile connectivity to the site and make provisions for approach to the site if required.

2.4.3 Weather and climate

2.4.3.1 *Solar radiation*

The average all sky surface shortwave downward irradiance is 5.1 kWh/m^2/day with a minimum value of 3.86 kWh/m^2/day in the month of December and a maximum value of 6.56 kWh/m^2/day during May. The average clear sky surface shortwave downward irradiance is 6.38 kWh/m^2/day with a minimum value of 4.14 kWh/m^2/day in the month of December and a maximum value of 7.99 kWh/m^2/day during May. The monthly average solar radiation (kWh/m^2/day) profile is presented in figure below.

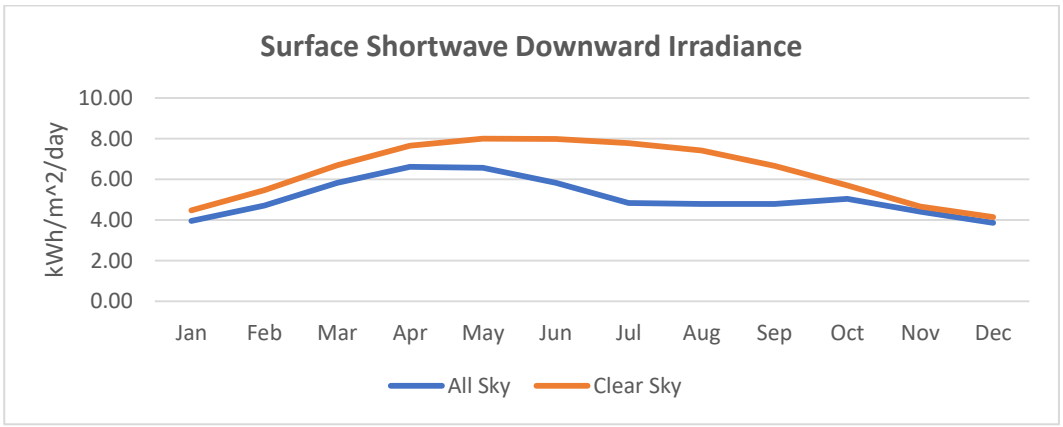


Figure19: All sky and clear sky shortwave downward irradiance (kWh/m^2/day)

2.4.3.2 *Ambient temperature (As per Govt data)*

The site experiences sub-zero ambient temperature for six - eight months in a year (January to April and October to December). The monthly maximum and minimum temperature profile are presented in figure below. Maximum temperatures vary between 15 to 30 degrees while the minimum varies from about -7 degrees to 10 degrees.

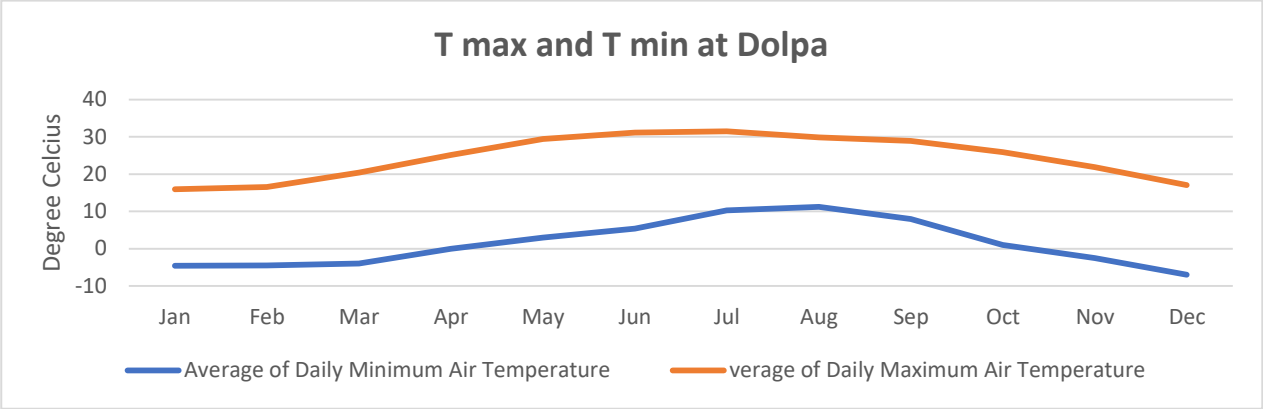


Figure: Average maximum and minimum ambient temperature at Dolpa site (Govt. Data)

Table: Temperature Data

Months	T_{max}	T_{min}
January	16	-4.6
February	17	-4.5
March	20	-4
April	25	0
May	29	3
June	31	5.4
July	32	10.3
August	30	11.2
September	29	8
October	26	1
November	22	-2.5
December	17	-7
Annual Average	24.0	1.36

2.4.3.3 *Basic wind speed*

The basic wind speed for higher hills is 55 m/s (~ 200 km /hour) as per NBC 104: 1994

2.4.3.4 *Snowfall and Rainfall*

The minimum ambient temperature of the site from November to April is 0°C to (-) 7°C. The area around the site receives up to 2 ft of snowfall for about 15 days in a year.

Average rainfall received at the site is about 30mm and historically it has varied between 4mm to 100mm. The data for over 60 years is presented in the figure below.

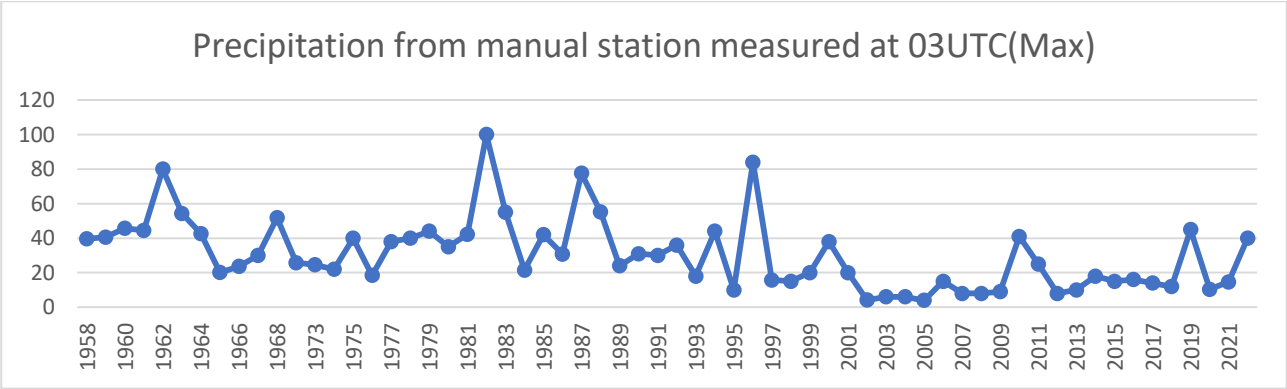


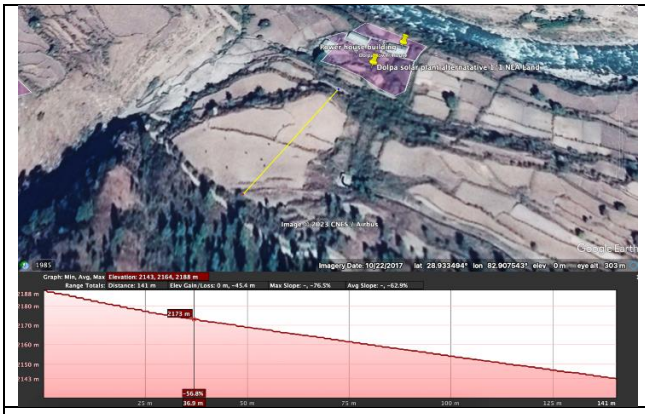
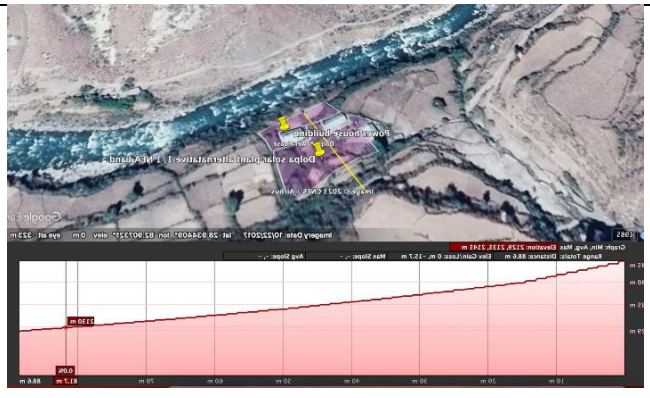
Figure: Rainfall data from 1958 to 2021

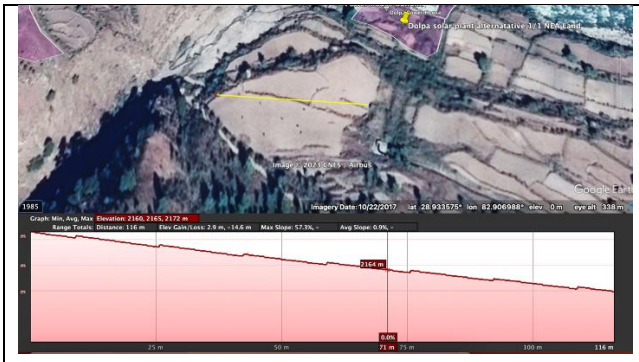
2.4.4 Topography and slope

The identified land parcel can accommodate about 650 kW (AC) PV arrays. BESS and control room can be established in the north part of the land. The site is divided into two parts, a bigger parcel at the southern side and a smaller portion in the northern side near the river. The land doesn't have much vegetation cover that would be needed to be removed. The land has minor undulations which can be addressed with little earthwork.

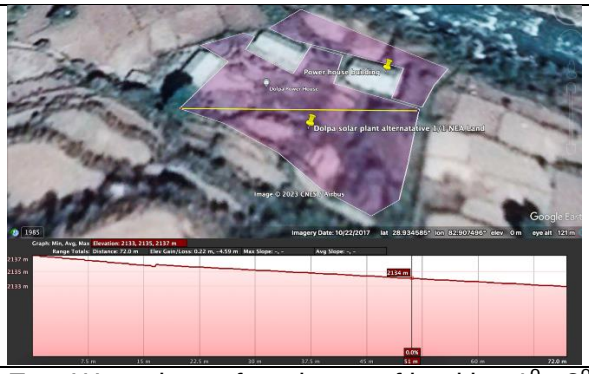
The southern land parcel has a slope towards the north with variation between 17^{o} to 22^{o}. The slope in the west to the east direction is between 7^{o} to 8^{o}. The northern land parcel has a slope towards the north with variation between 17^{o} to 22^{o}. The slope in the east to the west direction is between 1^{o} to 2^{o}. Slope analysis and contour map of the site are presented in the figures below.

The maximum elevation is 2180 m on the south and the minimum elevation is 2135 m on the north. Parallel contour lines indicate the slope from the south to the north is uniform throughout the site. No sign of water accumulation or flow across the site except the south part of the land parcel where water will flow from the west to the east. No risk of a landslide or erosion is foreseen.

	
South-North slope of the south part of land ~17^{o} - 22^{o}	South-North slope of the north part of land ~8^{o} - 11^{o}

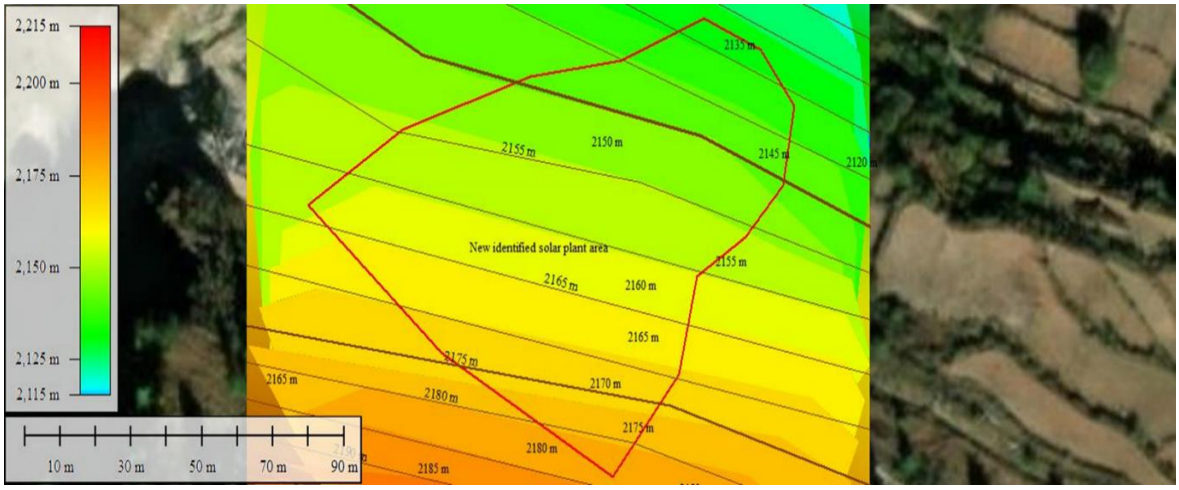


West-East slope of south part of land ~7^{o} - 8^{o}

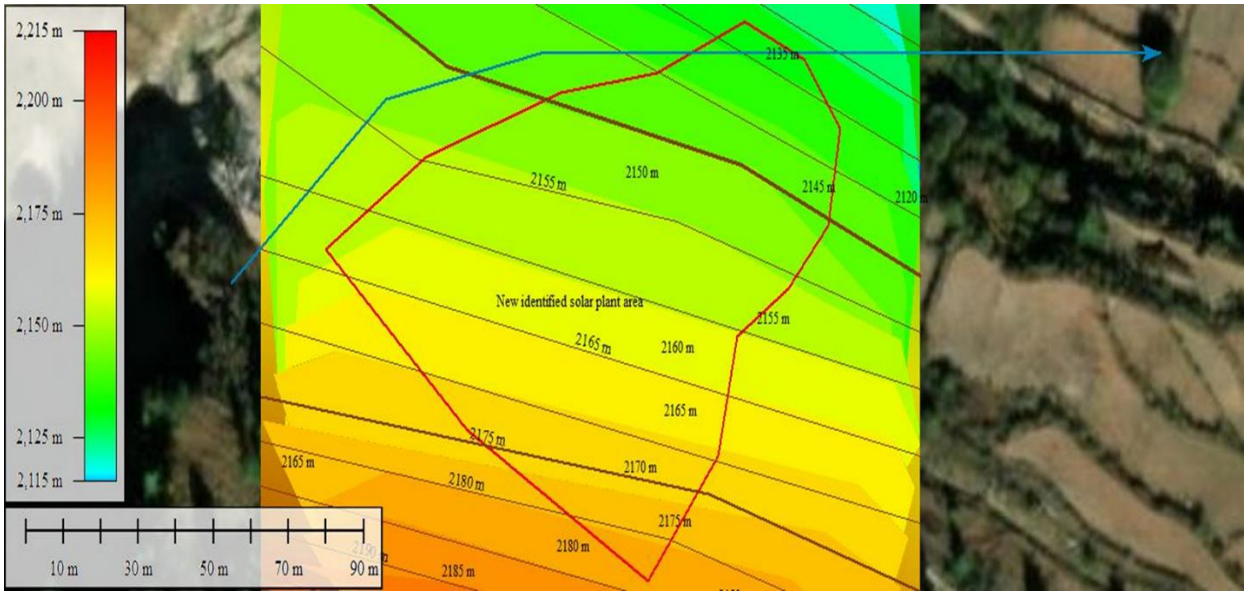


East-West slope of north part of land is ~1^{o} - 2^{o}

Figure 19: Slope analysis of two land parcel at Dolpa site



Contour map of Dolpa site and surrounding



Waterflow map of Dolpa site and surrounding

PV array layout in land parcel

Figure 20: Contour map, Waterflow map and indicative PV array layout at Dolpa site

2.4.5 Geotechnical information

High grade metamorphic rocks like slate genesis rocks exposed, silty soil with small pebbles seen on ground surface. (1m - 3m alluvial deposit with coarse gravel and sand followed by rock stretch (gneiss, quartzite, dolomite, phyllite). Seismic zoning factor as per NBC 105:2020 PGA =0.3g.

2.4.6 Load profile

The approximate number of households that will be connected to the PV-BESS system will be 3000 with an evening peak demand of 550 kW and a morning peak demand of about 400 kW. The existing 200 kW hydropower plant is working at 30% efficiency. A typical daily load profile and estimated generation profile of PV and hydropower plants are presented in figure 21.

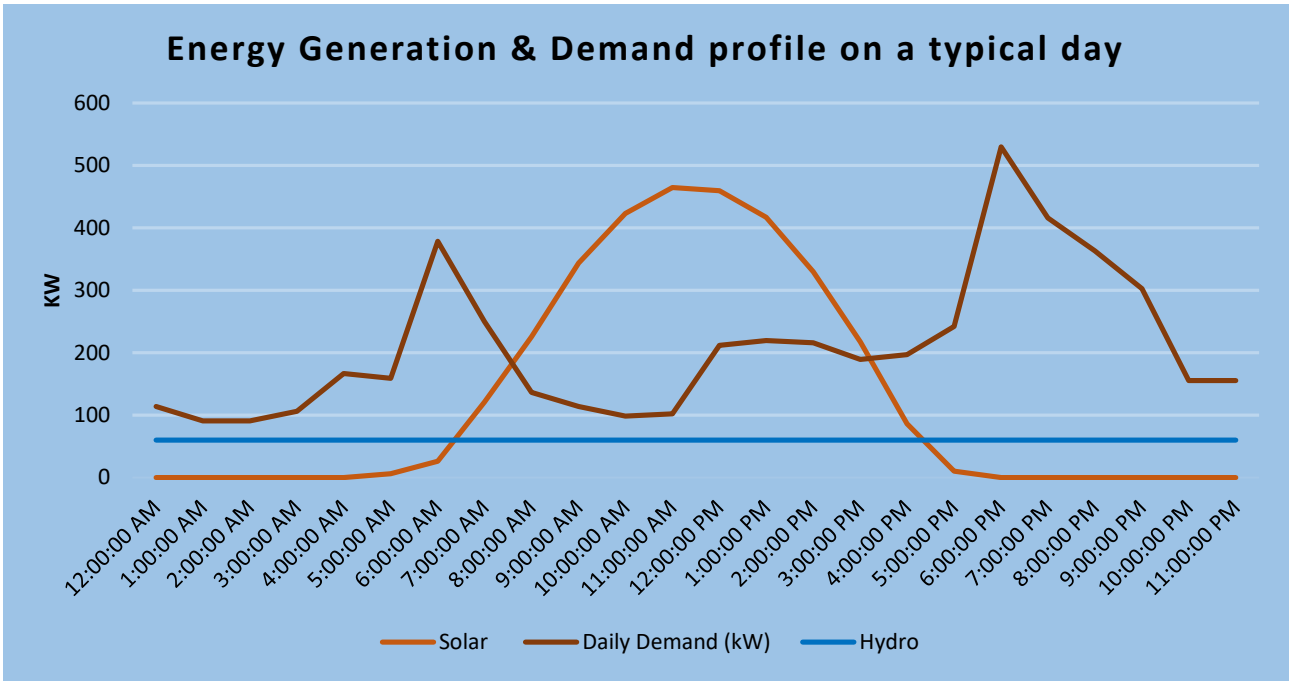


Figure 21: Typical daily load and generation profile Dolpa site

2.4.7 Grid Infrastructure

2.4.7.1 *Point of interconnection is to be made upto 11kV pole in the vicinity of the land parcel at each site. Connection beyond that point is the scope of the employer.*

2.4.8 Availability of power at the site

The area is powered by 200 kW Dolpa mini-hydro power plant. NEA substation is located near the proposed site. Contractor is expected to have a backup power required for their construction related purpose.

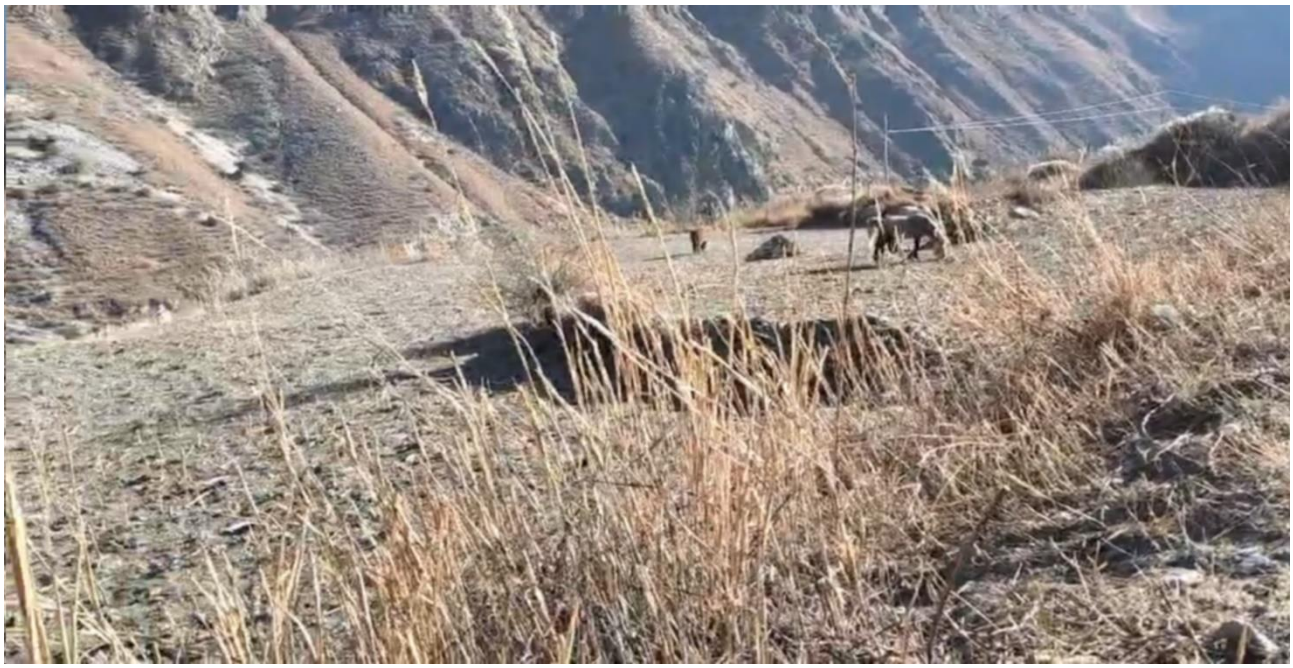
2.4.9 Availability of water and quality of water

Thuli Bheri River is nearby (approx. 100 m away) from the site. The contractor shall make provision for supply of water to the site if required for installation and construction activities.

2.4.10 Site Photographs

The land comprises of both NEA land and private land provided to NEA for 28 years.

Dolpa Site – Gentle slope (Southern land parcel)



Dolpa Site – Gentle slope (Southern land parcel)

2.4.11 Site clearance requirement

The block requires to be cleared of materials, shrubs, rocks, rubble etc. The site needs to be levelled as it has several undulations. The site clearance & dismantling shall be conducted with proper accounting in the presence of representatives of concerned office of NEA and the materials shall be returned to designated NEA stores at the expense of the contractor. Site pictures are attached below.

2.5 HUMLA

2.5.1 Location details

The general data of the site is shown in the following table below:

Table: General information of Humla site

Sl. No.	Site parameters	Details
1	Site Name	Humla
2	GPS Coordinates	29.9894N, 81.8436E
3	Elevation	3144 m
4	Number of consumers	5000 (projected)
5	Nearest Town	Simikot Town
6	Nearest metalled road	Karnali Highway (H13) is about 35 km (under construction) away and an earthen road from Tibet, China to Simikot.
7	Connecting road	Earthen road from Tibet, China (Hilsa) 4.5 m in width.
8	Nearest Airport	Simikot Airport is 3.2 km away from the proposed sites

Figure below shows an image of the site on Google Maps and the distance to the nearest airport.

Figure: Humla site shown in google map and distance to the nearest airport

2.5.2 Surface and air connectivity

The site is connected by an earthen road from Tibet, China (Hilsa) which is about 4.5 wide. Karnali Highway (H13) is about 35 km (under construction) away. Simkot Airport is 3.2 km away from the proposed site.

2.5.3 Weather and climate

2.5.3.1 *Solar radiation*

The average annual solar radiation at the horizontal surface is 4.77 kWh/m^2/day with a minimum value of 3.49 kWh/m^2/day in the month of January and a maximum value of 6.14 kWh/m^2/day during May. The average annual solar radiation at the tilted surface facing the equator is 5.22 kWh/m^2/day with a minimum value of 4.03 kWh/m^2/day in the month of July and a maximum value of 5.98 kWh/m^2/day during April. The Monthly average solar radiation (kWh/m^2/day) profile is presented in figure below.

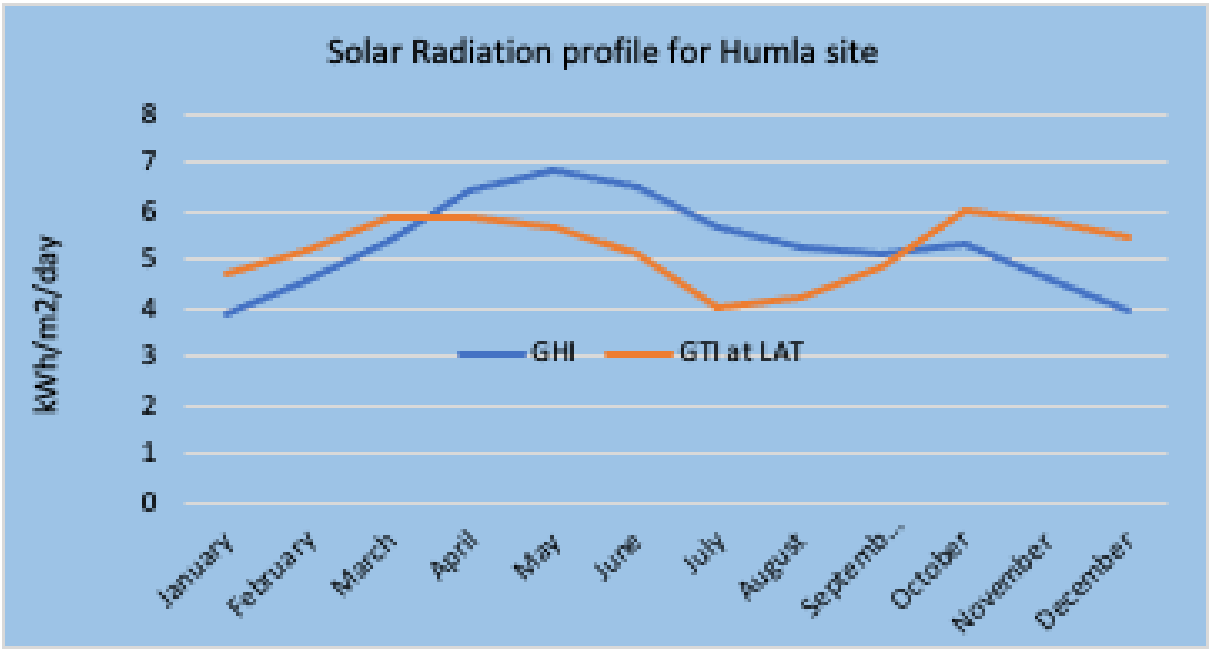


Figure: Solar radiation profile for Humla site
(Source: https://power.larc.nasa.gov/data-access-viewer/)

2.5.3.2 *Ambient temperature*

The site experiences sub-zero ambient temperature for eight to nine months in a year. The maximum temperature at the site is about 30^{o}C and is experienced in the months of June & July and the minimum temperature at site is about (-) 18^{o}C experienced in the months of December to February. The average monthly maximum and minimum temperature recorded over the last 33 years are presented in the figure below.

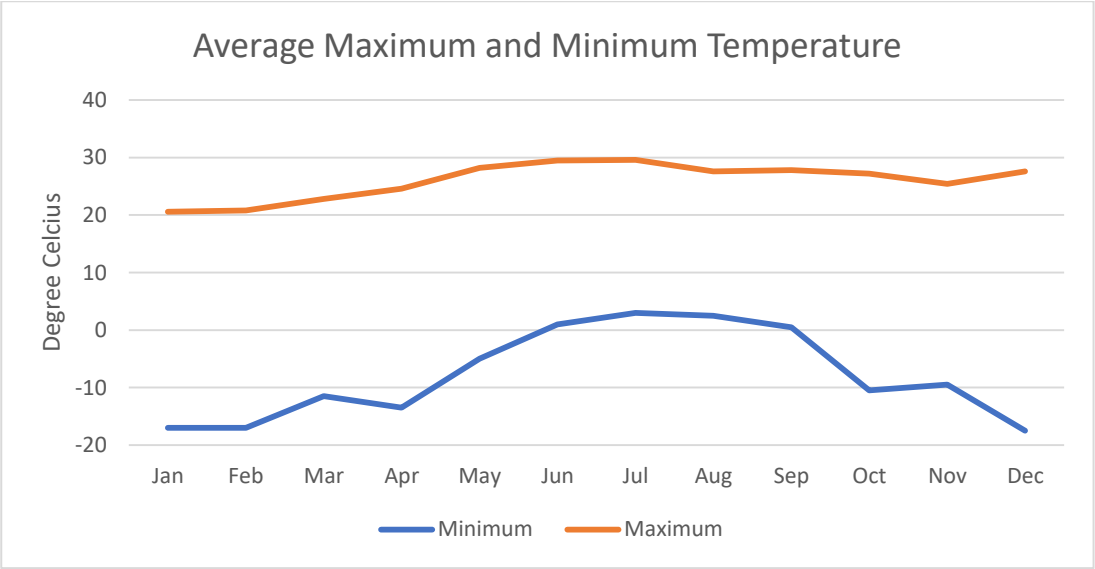


Figure: Maximum and minimum ambient temperature at Humla site
(Source: Government of Nepal Data)

Table: Solar and temperature data

Months	GHI ($kWh/m^2/day$)	GTI at LAT ($kWh/m^2/day$)	T_{max}	T_{min}
January	3.49	4.68	20.60	-17
February	4.21	5.15	20.80	-17
March	5.35	5.86	22.80	-11.5
April	5.91	5.88	24.60	-13.5
May	6.14	5.67	28.20	-5
June	5.63	5.1	29.50	1
July	4.34	4.03	29.60	3
August	4.39	4.2	27.60	2.5
September	4.68	4.81	27.80	0.5
October	5.04	5.98	27.20	-10.5
November	4.3	5.81	25.40	-9.5
December	3.76	5.43	27.60	-17.5
Annual Average	4.77	5.22	26	-8

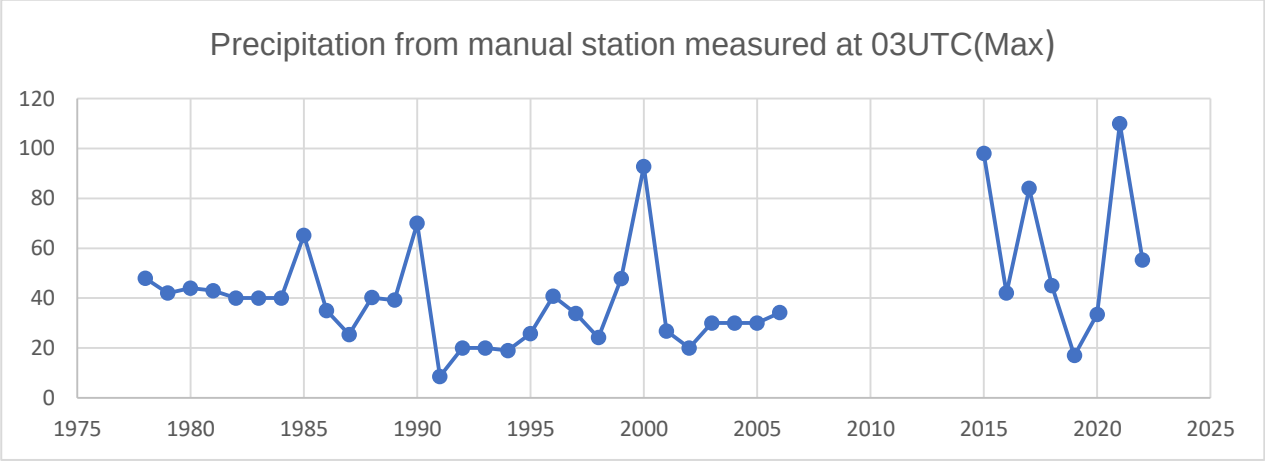
2.5.3.3 *Basic wind speed*

The basic wind speed for higher hills is 55 m/s (~ 200 km /hour) as per NBC 104: 1994

2.5.3.4 *Snowfall*

The minimum ambient temperature of the site remains sub-zero except in the month of July (0.11^{o}C). During this period snowfall occurs. Heavy snowfall occurs from November to April when the ambient temperature is (-) 16^{o}C to (-) 33^{o}C.

Average rainfall received at the site is about 40mm and historically it has varied between 9mm to 110mm. The data for over 44 years is presented in the figure below.



2.5.4 Topography and slope

The identified land parcel can accommodate more than 1000 kWp PV arrays. BESS and control room can be established in the north or east part of the land. The land parcel has a uniform slope towards the south at about 20^{o}. The slope in the east to the west direction is about 4^{o} in the north part and about 7^{o} in the south part. Slope analysis and contour map of the site are presented in the figures below.

Rainwater will flow at the site and the surrounding area predominantly from north to south. Since there is a large catchment area on the north and the site is in the middle of a mountainous slope adequate protection must be provided on the north side to protect the solar power plant from flash floods and possible erosion. The rainwater must be diverted/channelised at the north and east and west side of the land parcel.

Figure 22: Land parcel marked for installation of the solar power plant at Humla site

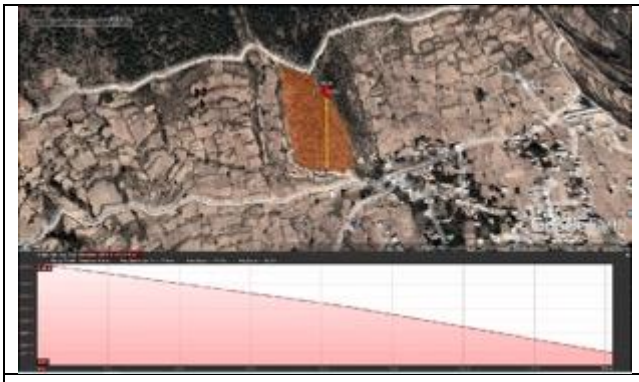
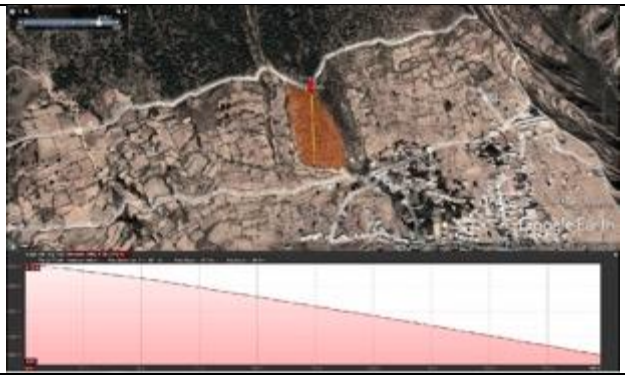
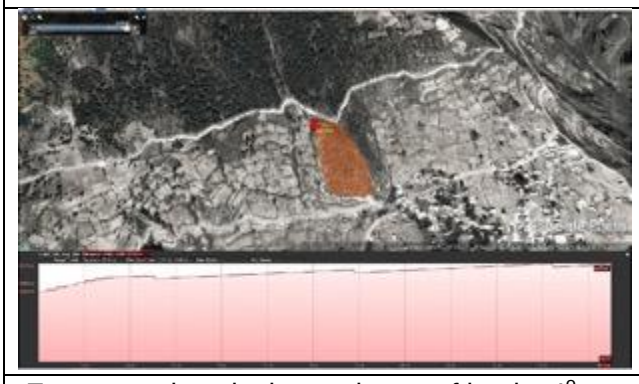
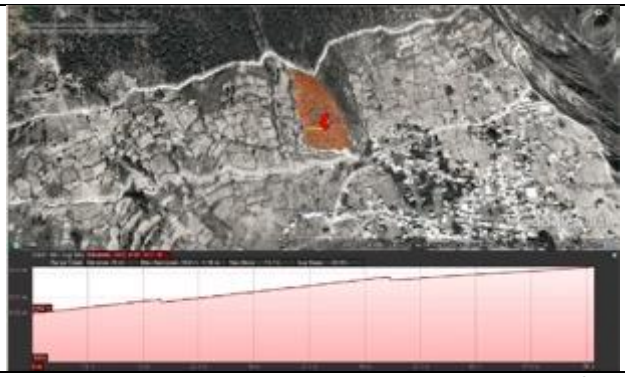
	
North-south slope in the west part of land is ~20^{o}	North-south slope in the east part of land is ~20^{o}
	
East-west slope in the north part of land ~ 4^{o}	East-west slope in the south part of land is ~ 7^{o}

Figure 23: Slope analysis of two land parcel at Humla site

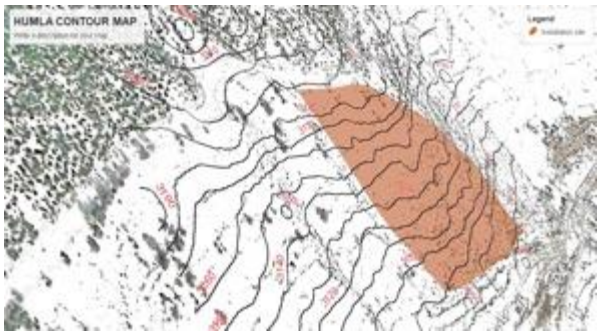
	
Contour map of Humla site and surrounding	Waterflow map of Humla site and surrounding
	
PV array layout and possible BESS location	PV array layout

Figure 24: Contour map, Waterflow map and indicative PV array layout at Humla site

2.5.5 Geotechnical information

1m - 5m alluvial deposit with coarse gravel and sand followed by rock stretch (gneiss, quartzite, dolomite, phyllite). Small pebbles of low-grade metamorphic rock like slates are seen. Some rocks are exposed which may be embedded 1 m to 1.5 m from the ground surface. Seismic zoning factor as per NBC 105:2020 PGA =0.25g

2.5.6 Load profile

The approximate number of households that will be connected to the PV-Hydro-BESS system will be 5000 with an evening peak demand of about 1100 kW and a morning peak demand of about 800 kW. The existing 500 kW hydropower plant is working at 50% efficiency. A typical daily load profile and estimated generation profile of PV and hydropower plants are presented in the figure.

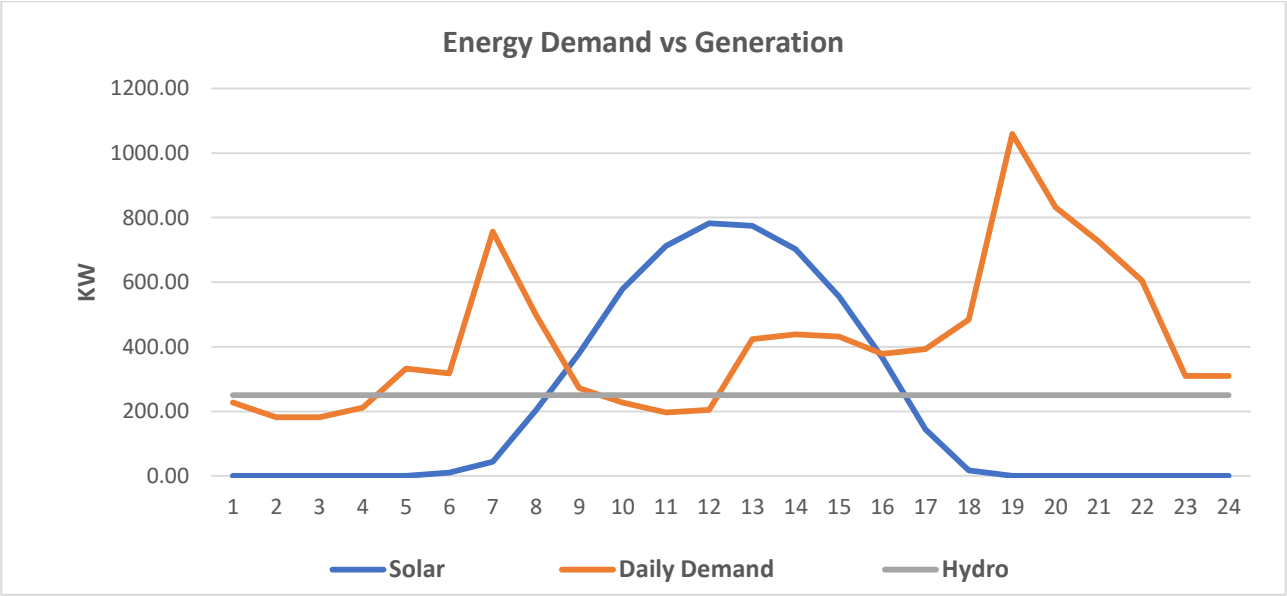


Figure: Typical daily load and generation profile Humla site

2.5.7 Grid Infrastructure

2.5.7.1 Point of interconnection is to be made upto 11kV pole in the vicinity of the land parcel at each site. Connection beyond that point is the scope of the employer.

2.5.8 Availability of power at the site

Electricity is available at the site from Heldung 500 kW hydropower plant.

2.5.9 Availability of water and quality of water

Tindhara spring source is about 50 m away from the site and Heldum river is about 1 km away from the site. Spring water is clean with mild hardness.

2.5.10 Site clearance requirement

The block requires to be cleared of materials, shrubs, rocks, rubble etc. The site needs to be levelled as it has several undulations. The site clearance & dismantling shall be conducted with proper accounting in the presence of representatives of concerned office of NEA and the materials shall be returned to designated NEA stores at the expense of the contractor.

3 Technical specifications

3.1 General

The following sections describe the general requirements for the design, manufacturing, installation, testing, commissioning and 3 years operation and maintenance support of photovoltaic solar system with battery storage having a provision for future synchronisation with existing & upcoming mini hydropower plants at all 4 sites.

Besides all the component specific documentation to be delivered, the Contractor shall also provide at least:

- For minimum technical requirements, "Data Sheets" as provided in following sub sections of employer's requirements (section 6).
- A general Layout showing the overall design of the solar PV system including PV array layout considering the site contour and slope, internal road, cable route, rainwater diversion plan, mounting structure, boundary, location of BESS, positioning of inverters, controllers, transformer, meteorological measurement station and grid connection of PV solar system. A two-dimensional drawing in PDF format is required.
- A detail site layout for all Contractor supplied equipment. This layout shall indicate any mandatory clearance requirements (e.g., for access, fire safety, etc.). The layout shall also indicate preliminary cable connections (i.e., identify which containers are connected).
- Proposed daily operation for the hybrid systems
- Mounting structure design with snow removal strategy
- A general single line diagram (SLD) of the overall system
- A single line diagram of the control panel
- A single line diagram of the interconnection points and switching mechanism
- Power plant control and monitoring system (PCMS) functioning logic chart
- Design for containerized solution including temperature control (HVAC) mechanism.
- Design for containerized office cum control room along with PCMS (with one small cabin for in-charge and a meeting room cabin)
- Design of storeroom and guard house.
- Design of modular containerized BESS housing including temperature control (HVAC) mechanism, smoke detection, fire detection and automatic fire extinguishing mechanism.
- Data sheets of all major equipment
- Sizing calculations
- Cable schedules
- Any other drawings and technical manual
- Anti-glazing studies wherein required

Moreover, the supplied equipment shall be designed and constructed to operate continuously, 24 hrs per day, 365 days per year without excessive maintenance or direct operator supervision.

The Contractor shall provide a detail site layout for all Contractor supplied equipment. This layout shall indicate any mandatory clearance requirements (e.g., for access, fire safety, etc.). The layout shall also indicate preliminary cable connections.

3.1.1 Units of Measurement

In all correspondence, technical schedules, drawings, and documents, and in all scales of the measuring instruments, the international system of units (SI) shall be applied unless otherwise required. The metric system and Celsius temperature shall be employed as the measurement units. If other units have been used in drawings and printed literature, the equivalent metric measurement must be included.

3.1.2 Language

All documents, and correspondence, including drawings, reports, schedules, and instructions, shall be written in English. Nameplates and rating plates, duty labels and instruction plates or labels and warning notices shall also be written in Nepali and English. The Contractor shall propose the entries, sentences, and wordings in English for the labels and plates to the Employer and/Employer's representative supervisor.

3.2 Photovoltaic Power plant

3.2.1 System Design

In general, the contractor will follow the following standards for designing the PV-BESS-hybrid systems. All design documents will be reviewed and approved based on these standards.

- IEC 62548: 2016 Photovoltaic (PV) arrays - Design requirements
- IEC TS 62738: 2018 Ground-mounted photovoltaic power plants - Design guidelines and recommendations
- IEC 60364-7-712: 2017 Low voltage electrical installations - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
- 16229: 2015: Balance-of-System components for PV systems - Design qualification natural environments
- IEC 62257-9 Recommendations for small renewable energy and hybrid systems for rural electrification –
    - IEC 62257-9-1 Part 9-1: Micropower systems
    - IEC 62257-9-2 Part 9-2: Microgrids
    - IEC 62257-9-3 Part 9-3: Integrated System-User Interface
    - IEC 62257-9-4 Part 9-4: Integrated System-User installation.

Also, if required, glare and glint analysis must be performed by the contractor at no additional cost to the employer.

3.2.2 **Photovoltaic Modules**

3.2.2.1 *General*

Monocrystalline silicon PV modules made of dual glass PERC bi-facial mono crystalline half cut cell that comply with IEC 61215 shall be used. Module efficiency should be more than 20% for effective utilization of land. All modules should include bypass diodes. **Only "Class A" modules according to IEC 61730-1 and IEC 61730-2 are considered.** The capacity of a single module shall be 400 Wp or more. All modules shall be from a single manufacturer with similar wattage and shall be with positive power tolerance only. Negative power tolerance shall not be accepted. Junction box and connector protection of PV modules shall be IP 68 rated.

3.2.2.2 *Material Warranty*

The manufacturer should warrant the Solar Module(s) to be free from (i) defects and/or failures due to manufacturing defects and/or failures due to materials, including PID defects and (ii) non-conformity to specifications due to faulty manufacturing and/or inspection processes for a period not less than ten (10) years from the date of sale. If the solar Module(s) fails to conform to this warranty, the contractor will replace the defective solar module(s) at site at no additional cost to the employer.

3.2.2.3 *Performance Warranty*

Performance of all PV modules shall be warranted with more than 97% power output in the first year, 90% power output for next 10 years and 80% of minimum rated power for the next 14 years

with not more than 0.6% degradation over a period of one year. If PV module(s) fail(s) to exhibit such power output in the prescribed time span, the Contractor will replace the PV Module(s) at site at no additional cost to the employer.

3.2.2.4 *Codes and Standards*

Valid test certificates for PV modules issued by ISO 17025/ ISO 17065 certified test laboratories must be provided at the time of detailed engineering. The authenticity and validity of the certificates will be verified. The Contractor shall also provide a factory test certificate for the electrical characteristics, of each solar PV module including current-voltage (I-V) performance curves and temperature coefficients of power, voltage and current at the time of Factory Acceptance Test (FAT).

The PV Module shall be designed, manufactured and tested in full compliance with the latest edition of the following, but not limited to, standards, codes, rules and regulations:

- IEC 61215: Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval
- IEC 61730 (Part 1): Photovoltaic (PV) Module Safety Qualification Part 1 Requirements for Construction
- IEC 61730 (Part 2): Photovoltaic (PV) Module Safety Qualification Part 2 Requirements for Testing
- IEC 61701:2020: Salt mist corrosion testing of photovoltaic (PV) modules
- IEC 60068-2-68:1994: Environmental testing - Part 2-68: Tests - Test L: Dust and sand
- IEC 62938:2020: Photovoltaic (PV) modules - non-uniform snow load testing
- IEC 62716:2013: Ammonia (NH3) Corrosion Testing
- IEC 62804-1:2015: Photovoltaic (PV) modules - Test methods for the detection of Potential-Induced Degradation.
- IEC 60529: Degrees of protection provided by enclosures (IP code)
- IEC 61345: UV test for Photovoltaic (PV) modules
- IEC 62790:2020: Junction boxes for photovoltaic modules - Safety requirements and tests
- Manufacturing facilities must be certified ISO9001 and ISO14001
- Test certificates must be issued by test laboratories certified under ISO 17025 or ISO 17065
- CE Certification

3.2.2.5 *Construction requirements*

The PV modules shall be installed according to manufacturer standards and guidelines using only manufacturer-approved components.

As the solar panels will be subjected to frequent snow and ice, please ensure:

• Appropriate Installation angle — to avoid large accumulation of snow on the panels (to reduce output limitations and structural damages).

• Proper Water drainage and waterproofing — to avoid accumulation of water in unwanted areas and, in turn, freeze-thaw damage.

Each module must be labelled indicating at a minimum:

- Manufacturer
- Type
- Serial Number

- Power rating under STC conditions
- Wp ± tolerance
- Maximum Power Point Current
- Maximum Power Point Voltage
- Open Circuit Voltage
- Short Circuit Current
- RFID tag

The contractor shall arrange an RFID reader at no additional cost to the employer to show the RFID details of the modules at the site.

PV Modules shall be provided with 4mm² fly leads and a cable length sufficient for the interconnection of modules into strings without any additional wiring. Connectors shall full fill the requirements of IEC 62852. Any modification to the PV module frame must be approved by the manufacturer in writing and shall not void warranty. Also, PV module grounding method shall be approved by the manufacturer in writing.

Integrated bypass diodes shall be installed in the junction box of every PV module.

3.2.2.6 *Tests*

Factory Acceptance Tests (FAT)

The test program for the Factory Acceptance Tests (FAT) shall be submitted to the Employer for approval at least 4 weeks prior to the start of the tests. The test report shall be submitted prior to the issuance of dispatch authorization for shipment.

The Employer reserves the right to visit the PV modules factory at any time during the manufacturing process to verify quality and timely production.

Proof of procurement of components as per the approved BOM mentioning manufacturer name, manufacturing date and relevant test certificate shall be submitted for verification.

The cells used for module making shall be free from all defects like edge chipping, breakages, printing defects, discoloration of top surface etc. The modules shall be uniformly laminated without any lamination defects.

Current binning of modules shall be employed to limit current mismatch of modules. Different colour codes shall be provided on the modules as well as pallet for identification of different bins. Maximum three numbers of bins will be allowed for each module rating.

Type Tests

Type tests and verifications according to applicable codes and standards are not required to repeat if a copy of the type test certificate is provided for the same model. If the type test has to be conducted by the contractor, it shall be at no additional cost to the employer.

Site Tests

The PV modules shall be tested at the site to ensure their performance during:

- Pre-commissioning
- Commissioning and test on completion

The site tests shall be witnessed by the Employer or their representatives. The commissioning test program shall be submitted at least 2 weeks prior to the start of the tests.

3.2.2.7 *Manufacturing*

All PV modules for this contract shall be manufactured in the same factory as approved by the employer.

3.2.2.8 *Documentation*

Complete documentation shall be provided for the design, manufacturing, testing, installation, commissioning, start-up, operation, maintenance, repair and disposal of the PV modules and their components.

The Contractor shall provide as a minimum the following documentation:

- Valid test certificates as per the standards mentioned above in clause number 3.2.2.4
- Technical data sheets
- Reports of tests and commissioning with protocols
- Flash test report
- Installation, operation and maintenance manual
- Factory testing quality protocol
- Guarantees
- CE Conformity Declaration
- Disposal schedule

Data Sheet for PV Module

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
1	**General data**				
1.1	Manufacturer				
1.2	Type				
1.3	Module description/technology				
1.4	Environmental conditions description		local conditions must be respected		
1.5	Special conditions		Snowfall, high humidity		
1.6	Min/Max operation temperature	°C	-45°C / +30°C		
2	**Electrical data**				
2.1	Maximum DC system voltage	V	1500		
2.2	Nominal power at STC	W			
2.3	Power tolerance ±	%			
2.4	Temperature coefficient P	%/°C			
2.5	Temperature coefficient V	%/°C			
2.6	Temperature coefficient I	%/°C			

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
2.7	Nominal Operating Cell Temperature (NOCT)	°C			
2.8	Module efficiency at STC	%	At least 20%		
2.9	Cable connectors (MC4)		From same manufacturer (and same manufacturer as DC cables connectors)		
2.10	Voltage at Pmax (V_e)	V			
2.11	Open circuit voltage (V_{OC})	V			
2.12	Current at Pmax (I_{MPP})	A			
2.13	Short circuit current (I_{SC})	A			
2.14	Peak Inverse voltage capability for bypass diodes (if applicable)	V			
2.15	Number of bypass diodes (if applicable)	No.			
2.16	If crystalline Modules are used: Number of cells per module	No.			
2.17	Total number of modules installed	No.			
2.18	Total installed capacity STC	kW			
3	**Mechanical Data**				
3.1	Height / Width / Depth	mm			
3.2	Weight	kg			
3.3	Front cover material				
3.4	Back cover material				
3.5	Frame material (if applicable)				
3.6	Maximum admissible Wind loads	Pa			
4	**Quality Data**				
4.1	Safety class		II		
4.2	Required IEC 61730 certificate		yes		
4.3	Required IEC 61215 or IEC 61646 certificate		yes		
4.4	Required IEC 61701 certificate		yes		
4.5	Product warranty	Years	Minimum 10 years		
4.6	Power guarantee	%/Year	guaranteed linear degradation with more than 97% power output in the first year, 90% power output for next 10 years and 80% of minimum rated power for the next 14 years with not more than 0.6% degradation over a period of one year		
4.7	Recycling guarantee / certification		yes		

3.2.3 **DC Cabling/AC Cabling**

3.2.3.1 *General*

All DC string cables shall be of PV1-F type.

DC Cables shall be designed to have losses of less than 3 % for the whole DC cabling system, starting from the PV array till the inverter DC input. Cable loss calculation is subject to prior approval by the Employer.

Any cabling shall be placed in conduit and firmly attached to the mounting structure or laid down in cable ducts out of direct sunlight and away from access by vandals.

All DC cables shall be installed to provide as short runs as possible. Moreover, positive and negative cables of the same string or main DC supply shall be bundled together to avoid the creation of loops in the system (reduction of the induced voltage surge due to lightning).

Long DC cable runs to be in earthed metallic cable trays to attenuate surge suppression.

All DC cables shall be permanently shaded from UV radiation. Between mounting structure or PV modules, a tube shall be used for protection of the cables.

The conductors of the cables shall be made of annealed copper in accordance with IEC 60228 in a flexible UV-resistant sheath.

The arrangement of modules on the mounting structure and their interconnection shall be designed to enhance servicing and inspection.

All string and main cables must be permanently labelled on both ends. Cables shall be labelled in such a way that the corresponding string and inverter can be identified.

3.2.3.2 *Cable Connections*

DC cable connections on string level shall be realized with connectors.

Only one type of connector for the positive (+) and negative (-) sides shall be used for all installations.
Any additional connectors plus the necessary crimping tools shall be provided at no additional cost to the employer.

Connectors shall fulfil the requirements of IEC 62852.

All connectors shall be of the same brand and manufacturer. Connectors which are compatible but not of the same brand shall be not allowed.

The termination of cables at the inverter shall be performed as per instruction of the manufacturer. If special connectors are required, they are to be supplied by the contractor at no additional cost to the employer.

Data Sheet for Cables

				To be filled by Bidder	
	Description	**Unit**	**Requirements**	**Data**	**Note**
1	**General**				
1.1	Manufacturer				
1.2	Environmental conditions				
2	**Standards / Specification**				
2.1	Specification				
2.2	Standards				
2.3	Voltage Grade	V	minimum 1000 V		
2.5	Cable length	m			
2.6	Number of cores				
2.7	Conductor				
2.7.1	Cross Section	mm^2			
2.7.2	Material				
2.7.3	Shape				
2.8	Insulation Material				
2.9	Armour material				
2.10	Outer Sheath material				
2.11	Cable gland size/dimensional details				
2.12	Minimum bending radius (during laying)				
2.13	Type test certificates				
2.14	Routine tests				
3	**Special Characteristics**				
3.1	Flame retardant		For all above ground cables		
3.2	Saline protection		For all buried cables		
3.3	Colour coding				
3.4	Derating factors				

HT/LT AC Cabling:

LT AC Cables:

Cable sizes shall be selected considering the power loss, current carrying capacity, voltage drop, maximum short circuit duty and the period of short circuit to meet the anticipated currents.

- Cables shall be 1100 V grade, multicore, XLPE insulated with extruded PVC inner sheath.
- The conductor shall be high conductivity annealed copper and shall be smooth, uniform in quality and free from scale and any defects.
- The maximum conductor temperature shall not exceed 90 degree C during continuous operation at full rated current. The temperature after short circuit for 1.0 second shall not exceed 250 degree C with initial conductor temperature of 90 degree C.
- Cables shall be armoured with mild steel wires or strips as required for underground and in trench installations.
- All cables shall be installed in HDPE conduit rather than direct buried to increase service life and ease of future replacement.
- Underground cables and cable joints shall be marked on the surface by markers generally manufactured and tested to the requirements of relevant standards.

- All cable terminations shall be mechanically and electrically sound and shall comply with relevant standards and NEA regulations.

Applicable Standards For Low Voltage AC Cables

IEC 60840	XLPE insulated PVC sheathed cables for working voltages upto and including 1100 volts.
IEC 60502	Recommended current ratings for cables
IEC 60228	Conductors for insulated cables.

11 Kv HT XLPE POWER CABLE

CABLE CONSTRUCTION DETAILS

The XLPE insulated cables shall conform to the requirements of IEC 60502-2 (applicable clauses only) for construction and IEC 60840 and other relevant standards for testing. The terminating accessories shall conform to IEC 60840/ IEC 62067 (as applicable). The offered cables and its terminating accessories shall be compatible with each other.

The 11kV XLPE cable shall be three core, armoured, stranded, compacted aluminium conductor, core screening by a layer of semiconducting XLPE, treeing resistant XLPE insulation, insulation screening by a layer of semiconducting XLPE. The core screening, insulation and insulation screening to be triple extruded and dry cured. Helically wound copper wire screening with equalising tape, shall be provided on each conductor. The oversheath shall be black HDPE. Bidder may offer necessary layers such as water blocking, separation tape, binder tapes etc. additionally as per their manufacturing practices for meeting required performance of the offered cable.

The cable shall be suitable for installing in the site-specific climate conditions. Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

Cable sheath shall be embossed "ELECTRIC CABLE 11000V". In addition the manufacturer and year of manufacture shall be embossed on the cable at regular intervals and shall not affect the spacing of the other characters. Each core shall be identifiable throughout the cable either by colour or numbering. Repaired cables shall not be accepted. Allowable tolerance on the overall diameter of the cables shall be as per IEC.

CONDUCTOR

The shape of conductor shall be compacted having high compactness and smooth surface finish.

CONDUCTOR SCREEN

The conductor screen shall consist of extruded semi-conducting XLPE. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor XLPE. The conductor screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids. The aluminium conductor shall comply with requirements specified in relevant IEC with latest amendments.

INSULATION

The conductor screen shall consist of extruded semi-conducting tape or insulation. Semi-conducting separator tapes may be applied between conductor and the extruded semi-conductor insulation. The conductor screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

The insulation shall be suitable for HT system voltage and the insulating material shall be cross linked Poly Ethylene (XLPE), and applied by extrusion process as per IEC and its latest amendments.

The insulating material shall have excellent electrical properties with regard to resistivity, dielectric constant and loss factor and shall have high tensile strength and resistance to abrasion. This shall not deteriorate at elevated temperatures or when immersed in water. The insulation shall be fire resistant and resistant to chemicals like acids, alkalis, oils and ozone.
The insulation properties shall be stable under thermal conditions arising out of continuous operation at conductor temperature of 90°C rising momentarily to 250°C under short circuit conditions. It shall be free from any foreign material or porosity visible to the unaided eye. The insulation shall be so applied that it fits closely on the conductor and it shall be possible to remove it without damaging the conductor.
The average thickness of insulation shall not be less than the nominal value as specified in relevant IEC with latest amendments.
Tolerance on insulation thickness shall be as per relevant IEC. The insulation shall withstand mechanical and thermal stress under both steady state and transient operating conditions.

INSULATION SCREEN

The insulation screen shall consist of extruded semi-conducting XLPE. Suitable bedding tapes shall be applied over the extruded semi-conducting XLPE in combination with 1 non-magnetic metallic shield.

INSULATION and Semi Conducting SCREENs
The XLPE insulation and semi conducting screens shall be triple extruded and dry cured.

MOISTURE BARRIER
Longitudinal water barrier:
The longitudinal water barrier shall be applied over insulation screen by a layer of non-woven synthetic tape with suitable water swellable absorbent.

METALLIC SCREEN:
The metallic screen shall be of plain copper wires, helically applied over the radial moisture barrier. A binder tape of annealed plain copper shall be applied in the form of an open helix over the copper wire screen.
The short circuit current rating for the XLPE cables at maximum temperature of 250 deg.C shall be as specified below.

Conductor Size (1s) (mm²)	Short circuit current (1s) (kA)
150	14.17
300	28.34
400	37.79

OUTER SHEATH

The outer sheath shall consist of extruded black coloured HDPE. The outer sheath shall be suitably designed by the addition of chemicals in the outer sheath for protection against termite and rodent attack.

Armouring:
The armour of cables shall consist of aluminium wires or strips. The armouring shall be applied such that the minimum area of coverage shall be 90% and the gap between any two armour strips/ wire shall not be more than the width of strip/ diameter of armour wire. The galvanized steel strips/wire shall comply with the requirements of IEC with latest amendments.
In case of Single core cable armouring shall be of Non-magnetic material with dimensions as per relevant IEC with latest amendments. No tolerance on the negative side shall be acceptable.

RATING
The contractor/ manufacturer shall declare current rating of cable for maximum conductor temperature of 90 degree C under continuous operation and 250 degree C during short-circuit condition. The contractor/ manufacturer shall also declare over load curve with duration for conductor temperature of 105 Deg C. A complete set of calculation made in arriving at the current rating shall be furnished, for laying condition envisaged under the project, during detailed engineering for Employer's reference.

CABLE JOINTING ACCESSORIES
The cable jointing accessories shall include all the straight through joints. Bidder shall arrange all special tools and tackles required for making these joints at his own cost. Cable end terminating kits shall be deemed included as part of cable jointing accessories.

Straight joints shall be heat shrink type with compression ferrules. Each joint shall include all necessary material and components for effecting a reliable and durable joint. Particularly importance is attached to the proper provision of stress relieving materials and tubing. The cable end terminals for terminating the cables shall be complete with accessories & fully compatible with the cables to be supplied. The terminations shall also be capable to withstand mechanical forces during normal and short circuit operations.

3.2.4 **Mounting Structure**

3.2.4.1 *General*

Selection of the PV array mounting structure should be properly done for the stability and long life of the solar PV plant. The PV module mounting structure shall meet and comply with the requirements of the PV module manufacturer. Further, the mounting system shall be certified by UL or an approved testing agency to meet the requirement of UL 2703.

The following factors shall be considered while selecting the PV array mounting structure for the site suitable for dual glass bifacial PV modules.

3.2.4.2 *Wind loading*

As per Nepal National Building Code NBC 104: 1994 (Wind Load) the basic wind speed for all four sites is 55 m/s (~ 200 km /hour). The PV module mounting structure shall be designed to withstand a minimum wind speed of 200 km/h for all four sites. Foundation must be designed considering the soil properties, snow level, icing and design loads accordingly.

3.2.4.3 *Snow loading*

Accumulation of snow on PV modules may lead to damage in the long run. In order to avoid high snow loading on the PV modules, a steeper tilt angle of 30^{o} shall be used. This will help in the self-removal of snow. The mounting tables must be designed to install PV modules in landscape orientation using vertical rails. Due to the presence of multiple diodes in the modules' junction box, there will be minimum generation loss due to shading from snow deposition at the lower side of the PV modules. On the other hand, vertical rails will be used to fix the modules, maintaining a gap of a minimum 25 mm between them. This will expedite the melting or shedding of snow deposited on the PV modules.

Portrait mounting of PV modules is not recommended for this site, not just to minimise energy generation loss but to also avoid hotspot formation and premature degradation of PV modules from partial shading. The table size should be smaller, and short in length and not more than two modules will be installed in landscape. The purpose of having a smaller table is the convenient installation on an uneven ground surface without earthwork, levelling of PV modules without deflection and convenient transportation in difficult terrain. A conceptual mounting structure table is given below.

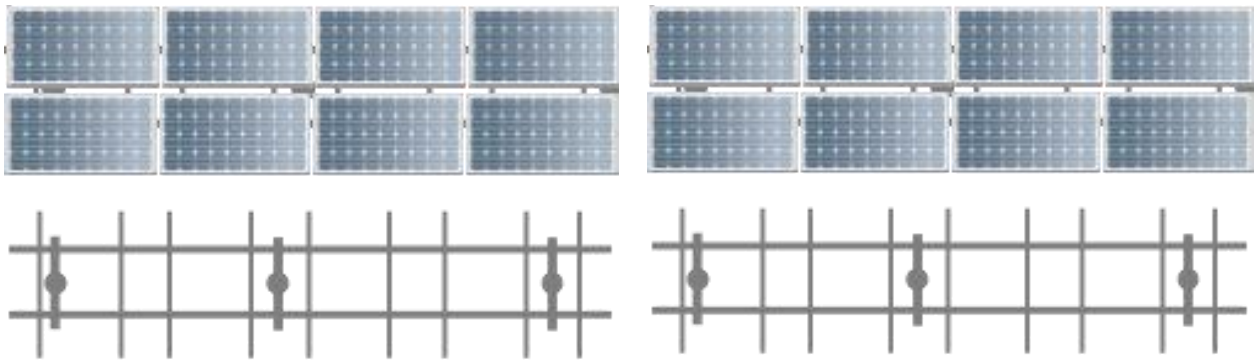


Figure 25: Conceptual drawing of PV array mounting structure

3.2.4.4 *Foundation*

Foundations are required to provide support to the module mounting structure. There will be a suitable number of poles per the table size with RCC foundation blocks of size to be determined based on soil property and other environmental parameters. The base of the pole will have provision for adjusting the height of the pole to minimise earthwork for levelling. Also, the mounting system foundation shall be designed to withstand frost heave and potential soil corrosion of the site and shall consider the geotechnical studies to be conducted by the contractor. Further, the detailed structural analysis of the foundation with details to show its conformity to applicable standards and codes are to be submitted for approval by the contractor.

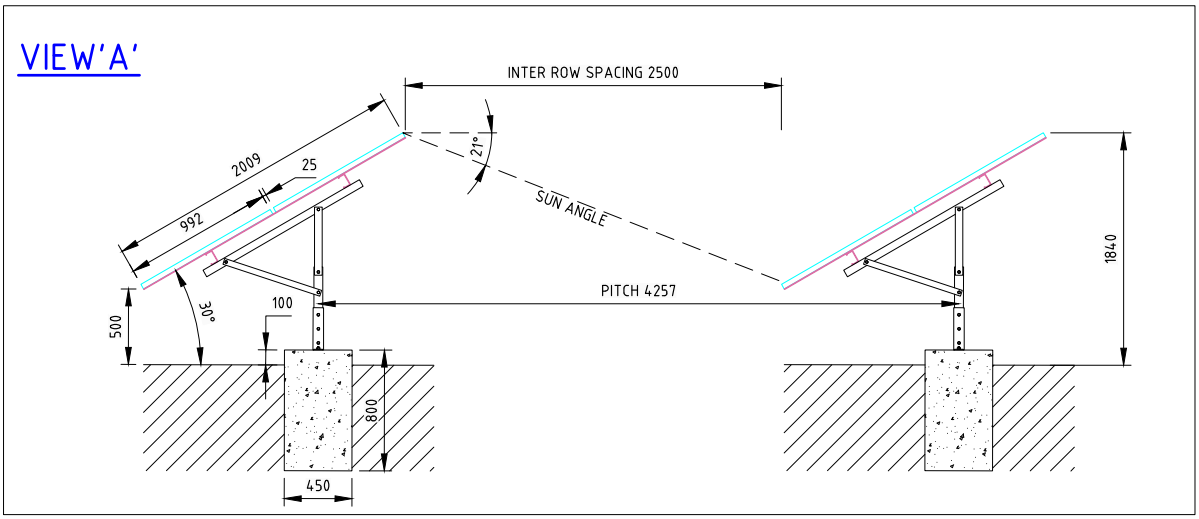


Figure 26: Conceptual drawing of mounting structure with foundation. The figures may change considering the site condition and yield possibility of the panel.

3.2.4.5 *Materials*

The structure will be designed to last for the complete 25 years of project life span; hence it should be free from corrosion. "Hot Dipped Galvanised Iron (HDGI)" structure with "Stainless Steel (SS)" nut bolts and fixing arrangements for the proposed solar PV plants. The thickness of the galvanised coating shall be more than 120 microns.

Any contact between unlike metals shall be avoided by use of suitable insulation materials like plastic or rubber separation strips. The Contractor shall propose its mounting structure concept and design for Employer's approval.

3.2.4.6 *Cable duct*

The mounting structure shall be provided with an adequate size/number of cable ducts for the installation of the cables between PV modules and the junction boxes or inverters. The installation of the cable ducts shall facilitate easy maintenance work. The mounting structure shall be connected to the earthing system by an appropriate arrangement.

Data Sheet for Mounting Structure

				To be filled by Bidder	
	Description	**Unit**	**Requirements**	**Data**	**Note**
1	**General**				
1.1	Manufacturer				
1.2	Type				
1.3	Structure description/technology				
1.4	Azimuth and Inclination				
1.5	Material Profiles		HDGI		

1.6	Material Nuts, Bolts, Screws and other Fasteners		Stainless Steel		
1.7	Environmental conditions description		local conditions must be re-spected		
1.8	Special conditions		Heavy snowfall, high humidity, 200 km/hour wind speed		
2	**Construction data**				
2.1	Single table size (Length x Width)				
2.2	Maximum number of module orientation in one row		2 x Landscape		
2.3	Gap between two modules for self-removal of snow				
2.4	Foundation type				
2.5	Foundation size (dimension)				
2.6	Overall structure is designed to withstand wind velocity of		200 km/ hour		
2.7	Gap between two rows	mm	100		
2.8	Type of Fasteners				

3.2.5 **PV Inverters**

3.2.5.1 *General*

This Section describes the requirements for the design, manufacturing, installation, testing commissioning of the inverter to be provided for the solar PV system. The technical data of inverters shall provide detailed information for proper planning, execution of construction work, commissioning, service and maintenance. The cumulative installed nominal AC output power of the inverters shall be suitable for PV module output in all ambient conditions without clipping of system output with a minimum AC/DC ratio of 0.9.

The inverters shall be selected and sized by the contractor to ensure safe and efficient functioning together with the PV solar system electrical characteristics (among others for the Maximum Power Point (MPP) range in accordance with the climatic conditions prevailing on the site. The contractor shall use multi-string inverters (inverters with multiple MPPTs) of DC input capacity, not more than 10 kW per MPPT. The inverters shall be equipped with string level disconnectors. and residual current monitoring capabilities.

3.2.5.2 *Codes and Standards*

The inverters should be TUV-tested for the required Certificates, CE-marked and in compliance with the applicable standards. Further, the inverter shall be designed, manufactured, and tested in full compliance with the latest edition of the following, but not limited to, standards, codes, rules and regulations:

- DIN / VDE 0126-1-1 Automatic disconnection device between a generator and the public low-voltage grid
- DIN EN 50178: Electronic equipment for use in power installations
- DIN EN 50524 Datasheet and nameplate for photovoltaic inverters
- EN 50530: Overall efficiency of photovoltaic inverters
- EN 61000-6-4/A1: Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
- IEC 60146-1-1: Semiconductor convertors - General requirements and line-commutated convertors - Part 1-1: Specifications of basic requirements
- IEC 60529: Degrees of protection provided by enclosures (IP code)
- IEC 61140: Protection against electric shock - Common aspects for installation and equipment
- IEC 61683: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
- IEC 61727: Photovoltaic (PV) systems – Characteristic of the utility interface
- IEC 62093: Balance-of-system components for photovoltaic systems - Design qualification natural environments
- IEC 62109-2: Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
- IEC 62116: Testing procedure of islanding prevention measures for utility-interactive photovoltaic inverters
- IEC 61000-6-2: Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments
- IEC 61000-6-4: Electromagnetic compatibility (EMC) - Part 6-4: Generic standards – Emission standard for industrial environments
- IEC 61400-21: Harmonics

- 519-2014 - IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
- IEC 62910 - Utility-interconnected photovoltaic inverters – Test procedure for low voltage ride-through measurements.
- IEC 60068-2-1 - an international standard for the environmental testing of electrotechnical products (Cold)
- IEC 60068-2-14 - an international standard for the environmental testing of electrotechnical products (Change of temperature)
- UL 1741: Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources

3.2.5.3 *Warranties and Certifications*

A product warranty of a minimum of five (5) years shall be provided. In addition, it should be possible to purchase an extended warranty of up to 20 (twenty) years.
Inverters should be approved by the module manufacturer for the compatibility; such documentary evidence is required to be submitted by the contractor upon award of contract.

3.2.5.4 *Components*

- All components of the inverters shall be selected considering easy maintenance, simple and quick diagnosis and long maintenance intervals.
- All components and equipment shall be designed for continuous operation at nominal feed-in under the given climatic conditions.
- All additional inverter components required to fulfil the applicable standards requirements shall be provided by the Contractor at no additional cost to the employer. These components are not limited to inverter inside installations.

3.2.5.5 *Euro-Efficiency of Inverter*

The minimum euro-efficiency of the proposed inverter shall be at least 98% (according to DIN EN 50524).

3.2.5.6 *Operating Conditions*

The inverters shall be designed and constructed for continuous operation under the climatic and environmental conditions at site. The system of protection shall be selected and coordinated in line with the feeding network data and the connected component requirements:

- To guarantee personnel and system safety.
- To ensure a sufficient protection against damages of the components, that might arise from the internal and external short circuits as well as from possible atmospheric discharges.
- To ensure as far as possible the continuity of operation for those parts not concerned by the fault. This will be achieved by selecting the setting in a way such that in case of a fault the closest protection device to the fault trips first.
- Overvoltage protection devices/function shall be included.

All components and devices shall have a durable, long-term stable, high quality protection coat according to environmental requirements. Damages, caused by transport, installation, cabling or commissioning shall be repaired in a way, that the original performance quality is restored.

3.2.5.7 *Technical Concept*

Only string inverter concepts are allowed. The contractor shall propose the most technically and economically suitable concept (taking into account the operation and maintenance requirement over the PV solar system lifetime). The local environmental conditions with also the remoteness of the sites shall be considered. The chosen inverter technology must be fully compliant with the proposed PCMS to provide optimized control of the PV-Hydro-BESS hybrid system and a reliable power supply.

The maximum DC/AC ratio of the inverter for the design of the PV system shall be 1.1 or less. Additionally, the contractor must ensure that there is no clipping of the PV power due to missing inverter capacity. Selected PV inverters shall have a maximum nominal AC rating of 50 kVA

For ease of operation and maintenance the following requirements shall be followed:

- all PV inverters shall be of same type, model, capacity from a single manufacturer approved by the employer
- all PV inverters installed must provide the capability to control the active power by frequency droop control.

3.2.5.8 *Inverter Housing*

The inverters have to be installed in order to withstand prevailing climate conditions. Minimum temperature of the sites is in the range of (-) 5^{o}C to (-) 10^{o}C. String inverter shall be installed outdoors with adequate protection (IP 65 or above) from the harsh climate. The PV inverters shall be protected by the rain and direct solar irradiation with a proper canopy. Minimum ground clearance from the inverter base shall be decided during detailed engineering based on local site condition. Logistic restrictions (max. weight and size which could be transported to the sites) must be considered. Necessary cable connection arrangements for incoming and outgoing cables shall be provided. Each inverter shall be connected to the grounding system with a copper cable of a minimum 6 mm^2 diameter. Manufacturer requirements shall be followed by the Contractor.

3.2.5.9 *Communication Protocol*

The communication between inverters and PCMS shall be realized with Modbus/Mbus. The inverter shall be able to be controlled via Modbus/Mbus communication by PCMS in order to reduce its output power if required to ensure isolated grid stability. Also, there should be provision for web based or App enabled use.

3.2.5.10 *Operation*

Under normal operation, inverters shall be capable of automatically synchronising with the isolated grid supply and exporting power to the isolated grid. All required functions shall be provided in the inverter for safe and reliable auto synchronization.

The contractor is responsible for the correct installation and operation of the PV inverters. Especially for the installation of the strings in various orientations and directions it must be respected, that only strings with the same orientation and inclination are allowed on the same MPP-Tracker. A

combination of strings with different orientations or inclinations on the same MPP-Tracker will not be accepted. The contractor is responsible to design the installation accordingly.

The Contractor shall submit an overall overvoltage and over-current protection design for the Employer's approval. All inverter incomers and outgoings shall be provided with sufficient overvoltage and over-current protection devices/functions. For the different strings that are connected in parallel to one MPP-Tracker, the number of modules in all strings must be the same.

The minimum temperature of the sites is in the range of (-) 5^{o}C to (-) 10^{o}C. While designing the string and a maximum number of modules, the voltage correction factor as per IEC 62548 shall be considered for the historically lowest temperature.

Inverter Total Harmonics Distortion (THD) shall be below 3%. The inverter shall be tested for electromagnetic compatibility in accordance with standards IEC 61000-6-2 (interference immunity) and IEC 61000-6-4 (interference emission). The maximum operating altitude without derating to be at least 3000 m. Also, the inverters shall be equipped with a ground fault detection and protection system.

3.2.5.11 *Tests*

Workshop/ Factory acceptance Tests

The Inverters shall be completely tested in the manufacturer's workshop in accordance with applicable codes and standards.

Type Tests

Copy of type tests certificates shall be provided for similar rating, if type tests have not been performed for the supplied rating, the contractor shall perform the type tests without any extra costs to the Employer.

Site Tests

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

- Pre-commissioning (including "loop testing")
- Commissioning and test on completion
- Unintentional islanding test

The site tests shall be witnessed by the Employer and or its representatives. The site test program shall be submitted at least two (2) weeks prior to start of the tests.

3.2.5.12 *Documentation*

Complete documentation shall be provided for the design, manufacturing, supply, installation, testing, commissioning, start-up, operation, maintenance and repair of the Inverters and their components.

The Contractor shall provide as a minimum the following documentation:

- Technical data sheets
- Inverter installation manual
- Layout drawings for all devices
- Single line diagrams

- Wiring diagrams
- Operation and maintenance manual
- Reports of tests and commissioning with protocols

Data Sheet for PV Inverter

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
1	**General**				
1.1	Manufacturer				
1.2	Type and product reference				
1.3	Inverter description/technology				
1.4	Environmental conditions description		local conditions must be re-spected		
1.5	Min / Max operation temperature	°C	-45° / ≥ +30°		
1.6	Location of installation (indoor / outdoor)		outdoor		
1.7	Special conditions		Heavy snowfall, high humidity		
2	**Electrical**				
2.1	Maximum DC voltage	V	1,000		
2.2	Nominal MPP voltage range	V			
2.3	Maximum DC current	A			
2.4	Number of DC inputs				
2.5	Protection value of each DC input	A			
2.6	Total nominal DC power	kW			
2.7	Nominal AC output power	kVA			
2.8	Maximum AC current	A			
2.9	Nominal AC current	A			
2.10	Nominal AC voltage	V			
2.11	AC Isolated grid frequency	Hz	50		
2.12	Power factors		Minimum 0.90 lagging, 0.90 leading		
2.13	Maximum THD	%	<3		
2.14	Minimum allowed Euro ETA	%	98		
2.15	Operation consumption	W			
2.16	Standby consumption	W			
2.17	Auxiliary power voltage	V			
2.18	Protection class (EN 60529)		IP65 or above		
2.19	Protection class (EN 60721-3)				
2.20	Height / Width / Depth	mm			
2.21	Weight	kg			
2.22	Total number of Inverters	No.			
2.23	Noise level	dB	≤ 60		
3	**Grid Connection Requirements**				
3.1	Frequency measurement average	ms	100		
4	**Interfaces**				
4.1	Communication protocol		Modbus/Mbus		
5	**Standards**				
	IEC 62477				
	IEC 61000				
	Any other standards as specified in 3.2.5.2				

3.2.6 **DC String Combiner Box / AC Combiner Box**

3.2.6.1 *Components and Equipment*

All components and equipment of the DC/AC combiner boxes shall be selected considering easy and long maintenance intervals as well as quick fault diagnosis. All components and equipment shall be designed for continuous duty at rated load and under the given climatic conditions. The Contractor shall ensure the interchangeability of components and equipment considering the same kind and type are selected for equivalent functions. Terminal blocks used in the DC/AC combiner box shall have sufficient voltage and current ratings as well as IP rating for outdoor installation.

All additional equipment such as fuses, monitoring devices, current transformers, circuit breakers and overvoltage protection shall be of superior quality and from reputable manufacturers. Any additional components, if required, shall be provided and installed by the Contractor at no additional cost to the employer. The DC/AC combiner boxes with IP 65 or above shall be equipped with hinged doors and fixed mounted internal components. The access to the combiner boxes shall be from the front side door only that shall have possibility to swing out at least 180°.

The cable terminal blocks shall be located in the lower part of the DC/AC combiner box and shall be sized in a manner such that an easy cable termination is possible. All cables shall be neatly and securely fixed within the DC/AC combiner box. Cable entry to the DC/AC combiner box shall be from the bottom side only using appropriate cable glands. No more than one cable per cable gland shall be allowed, the cable entries shall be watertight. The DC combiner boxes must be accessibly, securely and squarely installed, and in the shade and protected from snow and cold weather.

All the DC/AC combiner boxes shall have key locking facilities (e.g., padlock). All terminal connections in the DC/AC combiner box shall have proper identification number on the terminal block and wire. All screws, nuts and washers shall be hot dip galvanized and properly fixed. The combiner enclosure shall be outdoor rated NEMA 3R/4/4X. It shall also include a DC load break disconnect for isolation purpose.

3.2.6.2 *Electrical Requirements and DC/AC Junction Box Concept*

A specific number of strings shall be connected to one DC/AC junction box as well as a connection to the plant control and monitoring system. The Contractor shall optimize and define the location and number of junction boxes in order to minimize the power cable losses.

Overcurrent protection:

- For DC boxes: DC fuses for at least one polarity of each string connection according to the inverter and PV module manufacturers' recommendations. Each fuse shall be sized/rated by considering the fuse characteristic, module requirements, the minimum and maximum short circuit currents, the selectivity as well as requirements of the connected cable. Only PV string fuses of type g PV according to IEC 60269-6 shall be used. Blocking diodes may not be used in place of string fuses.

- For AC boxes: MCCB circuit breakers (fixed type) are mandatory (using fuse is not allowed)

Overvoltage protection:

- One (1) overvoltage protection per box. For DC boxes, PV specific surge arrester type 2 shall be provided. The overvoltage and short circuit protection devices shall be provided and shall be selected in line with the feeding network data and the connected equipment requirements:

Monitoring devices and disconnector for combiner boxes:

- Monitoring device in order to allow the detection of fault. The monitoring device shall be easily accessible and replaceable
- String monitoring device interface with PCMS (measurement of string currents) to allow the detection of faults
- One main ON/OFF disconnector per box

3.2.6.3 *Tests*

Workshop/ Factory Tests:

The DC/AC combiner box shall be completely tested in manufacturers' workshop/factory in accordance with applicable codes and standards.

Type Tests:

Type tests and verifications according to applicable codes and standards shall not be repeated, if a copy of the type test certificate is provided for same model. If type test is required, it shall be at no additional cost to the employer.

Site Tests:

The DC/AC combiner box shall be also tested at site to ensure proper functionality during e.g.

- Pre-commissioning
- Commissioning and test on completion

The site tests shall be witnessed by the Employer and/or their representatives. The commissioning test schedule shall be submitted by the contractor at least two (2) weeks prior to start of the tests.

3.2.6.4 *Documentation*

Complete documentation shall be provided for the design, manufacturing, supply, installation, testing, commissioning, start-up, operation and maintenance of the DC/AC combiner boxes and their components.

The Contractor shall provide as a minimum the following documentation:

- Technical data sheets
- Internal layout drawings showing all installed components
- Wiring diagrams
- Cable lists
- Spare parts list
- Operation and maintenance manual for all major equipment
- List of all minor components with manufacturer information
- Reports of tests and commissioning with protocols

3.2.7 **Meteorological Station**

3.2.7.1 *General*

The PV power plant shall be provided with a meteorological measurement station in each solar power plant site to monitor ambient and weather conditions with respect to below mentioned meteorological parameters.

The contractor is responsible for the installation of a meteorological measurement station minimum of four (4) weeks before commissioning (to ensure correct calibration of the system) of the PV power plant.

The power supply for meteorological measurement station shall be from UPS and a dedicated battery supplied and quoted under the item related to the supply of Meteorological Station by the contractor. The UPS & battery size shall be to provide a minimum of 5 days of continuous functioning with only the dedicated battery.

The meteorological station shall be installed by the contractor on a location where no shading from any building, light pole or any other obstacle is expected on the pyranometers or reference cells, nor from the meteorological station on the modules of the PV field.

3.2.7.2 *Technical Requirements for Type 1 meteorological stations*

The following specifications are for Type 1 meteorological station which shall be installed at all sites with NEMA 4X and UL 746C electrical enclosures.

1. **Global solar irradiation on horizontal plane:**
   - Two (2) pyranometers (ISO 9060 Secondary Standard): one for horizontal installation and one at the same orientation and inclination as the PV modules.
   - Metering range: 0 to 2000 W/m²
   - Overall accuracy: ± 2 % of metered value (daily average)
   - Spectral range 310 to 2800 nm

2. **Air temperature**
   - Overall accuracy: ± 0.5 °C
   - Metering range: - 40 to + 70 °C
   - Response time: 20 s (T90)

3. **Module temperature**
   - PT1000 adhesive foil resistor in 4 wire measuring technology
   - At least two (2) independent sensors shall measure the module temperature of the modules
   - Industry best practice to mount the temperature sensor to the module shall be used

4. **An anemometer mounted on a mast to measure the wind speed at the site**
   - Sensor type: Solid state magnetic sensor for wind speed
   - Wind vane and potentiometer for wind direction
   - Min. measurement range shall be 1…70m/s

- Wind direction range 0…360°
- The location of the mast shall be the same as the pyranometers.
- The mast shall be high enough, that there is no horizontal wind shadow from any other obstacles. Manufacturer's recommendations shall be followed by the contractor.

5. **Data Logger**

- The data logger shall be time synchronized
- Analogue inputs with a resolution of at least 16 bits
- Input voltage range: ± 10 mV to ± 10 V, full-scale
- Memory extension by using a SD card
- Interface Base: Modbus/Mbus
- Standard protocol: Modbus/Mbus
- Linearity: ± 0.01% Absolute Accuracy: 0.05%
- All analogue inputs shall be fault-protected against short-circuit, over-voltage, transients and electrostatic discharge.
- Data Storage Space: At least 1 GB
- Internal Memory: 4MB
- Keyword protected web and app-based application for Employer/Engineer
- Ambient temperature: -20 – 50 °C
- Humidity: up to 100% non-condensing
- Watch Dog Timer: Yes
- Data logger shall be compatible with the climatic conditions on site

3.2.7.3 *Enclosure and environmental conditions*

The PCMS shall be installed in a cabinet(s) in the containerized control room, including all necessary communication modules.

All additional equipment like servers for processing data and archive server, etc. shall be located in the same area. Field devices to gather all PV, meteorological data, hydropower generation data, BESS data, electrical feeder data, etc. should be installed close to the related areas.

The PCMS and associated accessories shall be accommodated in dedicated equipment cabinets for indoor application. The cabinets shall be constructed as follows:

- Standard sized steel cabinets with external painting colour as per Employer's approval
- Certified for minimum IP31 protection class
- Front-patches for LAN cabling
- Cable organisers, cable trays, suspensions and termination components with strain relief for all internal and external cabling
- 20 % housing space for future equipment
- Bottom cable access
- Grounding bus bar for earthing connection
- Power socket for maintenance
- Provision of easy access to maintenance and repair

3.2.8 **CCTV Camera & External Lighting System**

CCTV Cameras along with monitoring stations (sufficient numbers) and all other accessories required for its proper operation must be installed to have complete coverage of following areas for 24 hours.
(i) Main entry: Covering all the entry/exit
(ii) Along the Plant Perimeter: Covering complete perimeter of Plant Area to capture all possible intrusion
(iii) Control Rooms: Covering Entry/Exit and Equipment Rooms
(iv) Switchyard
(v) BESS container

Monitoring stations of the CCTV Network shall be installed in Main Control Room and should be accessible remotely via internet also.

The CCTV system shall be designed as a standalone IP based network architecture. System shall use video signals from different cameras at defined locations, process the video signals for viewing on monitors at control room and simultaneously record all video streams using latest compression techniques.

Camera shall be color, suitable for day and night surveillance (even under complete darkness) and network compatible.

It shall be possible to control all cameras i.e., PTZ auto/ manual focus, selection of presets, video tour selection etc. The software shall support flexible 1/2/4 windows split screen display mode or scroll mode on the display monitor for live video.

The system shall support video analytics in respect of the following:

- Video motion detection
- Object tracking
- Object classification
- Camera server shall be provided with sufficient storage space to store recordings of all cameras at HD mode for a period of 15 days. All recordings shall have camera ID, location, date and time of recording.

- The panel area (inter row pathway and peripheral pathway) shall be illuminated with external lighting system; utmost care should be taken for avoiding any shading effect due to the poles. All lighting equipment shall be LED luminaries. They must comply with IES LM 79-08 and IES LM 80—15 standards.

- All external lighting used on the project shall be International Dark Sky Association IDA certified.

- LED based system shall be used.

- IP Indoor Dome Camera 2MP Onvif Compliant.

3.3 Battery Energy Storage System (BESS)

The BESS mainly consists of the following parts:

- Batteries
- Battery Inverters/Chargers
- Housing

Definitions:

BESS – Transportable, containerized energy storage system based on commercially available electrochemical storage solutions, capable of receiving, storing, and delivering electrical energy at specified rate(s) suitable for the application laid out in the specifications herein. It comprises of unit batteries, battery management system (BMS), auxiliaries, such as HVAC and fire suppression systems.

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

PCS - Power Conditioning System - A switching power supply unit that enables bidirectional power conversion between AC and DC. It is the interface between the DC battery system and the AC system and provides for charging and discharging of the battery.

Plant Control and Monitoring System **(PCMS)** – The control logic is executed at PCMS. It will provide input signal to PCS for charge/discharge depending on control logic requirement.

A typical BESS includes:

- Battery modules – connected in series and parallel for required capacity.
- Containerized Storage enclosure with thermal management to maintain inside temperature as per site ambient temperature.
- PCS
- BMS
- PCMS

The system shall operate fully automated, be remotely monitored and be delivered as a turn-key system with 3 years of operation and maintenance support by the contractor at site.

The BESS is mainly designed to supply evening and morning peak loads and to support the hydropower generators with active and reactive power following the command of the Main Hybrid Controller (PCMS). The type of battery shall be a utility-scale battery that can deliver high power for a short period of time. The function of the BESS is to store and supply energy as required, in accordance with the hybrid power system's energy demand. The battery energy storage system shall perform but not be restricted to the following functionalities:

- Power balancing: The BESS shall ensure an instantaneous active and reactive balance between load and generation. The system shall stabilize the frequency of the grid independently of the changes in load or renewable generation systems.
- Contribution to voltage regulation: The power electronics part of the system shall contribute to the voltage regulation of the grid, performing proper management of the reactive power circulating in the grid.

A detailed concept of the battery monitoring system needs to be provided by the contractor.

General additional requirements for the system operation:

- The battery system shall be maintenance-free, meaning that no regular works or software updates shall be required for continuous operation.
- The contractor will inform about the requirement of preventive maintenance scheduling and the impact of these labours on the warranty terms and conditions of the system.
- The contractor will also inform about the indicated personnel to perform preventive maintenance tasks (manufacturer, certified sub-contractor, etc.)
- The battery system shall have a low environmental impact. A life-cycle assessment of the product design and all the environmental considerations will be supplied by the contractor.
- The contractor shall provide all the safety considerations of the battery manufacturer about the system and shall supply all the ancillary systems that may be needed to avoid the BESS system.
- The contractor shall have a program for battery dismantling and return to factory after its operation life.
- Cell and module design shall accommodate the anticipated vibrations and shocks associated with the transportation of the BESS and shall resist deterioration due to vibrations resulting from the same. Associated hardware and paraphernalia should also be able to withstand the rigors of transportation. It is highly recommended to make manufacturer highly aware of local road conditions for better design and supply.
- The Contractor shall provide the necessary preparations and required packaging of the system for transportation to the site.
- The Contractor is to ensure short-term and long-term storage requirements.
- The Contractor should ensure any specific requirements for long-term storage over several months.
- The Contractor is to take the measures in place or needed to maintain the battery State of Charge above its minimum value during long term storage (on site), if the system has not been connected to the main power grid and/or commissioned.
- Using industrial type air conditioner to effectively stabilize the temperature inside the container and makes the battery work at a suitable ambient temperature;
- Ensure the delivery of refrigerated air to each battery module through reasonable structural design.

3.3.1 **Batteries**

In accordance with the defined system operation, the chosen batteries are of the lithium-ion type; the number of strings is one of the decision variables that shall be optimized in the simulation pro-

cess by the contractor. The contractor shall select the most suitable product to meet the rated and peak charge and discharge power with the lowest kWh installed. The maximum discharge rate shall not exceed 1C.

The battery shall be composed of modular racks, which consist of several battery trays which are put together from modules which consist of lithium-ion cells. The modules, trays and racks shall easily be exchangeable on-site to improve reliability in case of fault and to facilitate the maintenance works. The battery management system (BMS) shall communicate via Modbus/Mbus /RS485/CAN with the PCMS.
The design of the BESS shall incorporate the principle of modularity, with a view to reducing life-cycle costs and ease of replenishment of storage capacity while facilitating ease of maintenance, space requirements, and reliability. The design should also facilitate rapid and easy replacement of the unit batteries without significant downtime.

The Battery Rack system design must allow for easy replacement and access to the battery modules for maintenance. The Contractor shall provide at no additional cost if there is any supplemental equipment required to remove Battery Modules. Also, the Battery Rack system should be designed to prevent propagation of fire or thermal runaway between the Battery Racks.

The applicable detailed specification of the battery is as mentioned below:

Item	Specification
Type	Lithium-ion (Li-ion) Battery with Prismatic Cell
Usable Battery Capacity	2200 kWh with a maximum 80% Depth of Discharge for Gamgadi, Mugu 3800 kWh with a maximum 80% Depth of Discharge for Jumla 2000 kWh with a maximum 80% Depth of Discharge for Dolpa 3000 kWh with a maximum 80% Depth of Discharge for Humla
Rated Capacity per cell	(Contractor's design x 1) Ah @ 1.0CA
Discharge per Cell	(Contractor's design x 1) Ah or more @ 1.0CA
Guaranteed Cycle Life	Minimum 6,000 cycles, at DOD (Depth of Discharge) 80% or above at rated power, and remaining battery capacity (State of Charge, SoC) shall be equivalent or above 80% at the end of the above life cycle. The contractor shall provide a lifetime graph from the manufacturer showing the number of cycles vs. DOD.
Minimum round-trip efficiency	85%
Design Life	Minimum 15 years
Operation Temperature	Charging (-) 0℃ to (+) 45℃ Discharging (-) 20℃ to (+) 45℃
Environmental Conditions	Operating Temperature: -20°C to +45 °C Relative humidity: 0 – 95% Altitude: up to 3000m
Off Grid Capable	Yes, with surge protection

3.3.1.1 *Standards for Battery Systems*

The following Code and Standards shall be applicable for the project as shown below:

Standard	Description
IEC 62133 or UL 1642	Safety requirements
IEC 62281 or UL 1973	Test methods and requirements to ensure safety during transport other than for recycling or disposal
UL9540A	Standard for Thermal runaway required for BESS system level
IEC 62620	Secondary cells and batteries containing alkaline or other non-acid electrolytes – secondary lithium cells and batteries for use in industrial applications
IEC 61508	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems: Applicable for all Battery Energy Storage Systems
IEC 61850	Communications networks and management systems. (BESS control system communication)
IEC 62933, IEC 92902	Provide overarching safety and environmental requirements for integrated systems. Address personnel safety, electrical hazards, essential grid protection functions, fire and explosion safety, hazardous materials, stand-off distances, installation and operation requirements.
IEC 61936-1	Ensure adequacy of workspaces, including protection from arc flash or exposure to electrical hazards, unrestricted access to emergency exits, and reduce risk of exposure to fire suppression systems.

3.3.1.2 *Battery Management System (BMS)*

The BMS shall (not limited to):

1. Control operating conditions -Measures voltage, current, and temperature signals and controls these parameters to achieve cell balance and prevent damage to the battery. Shall ensure that risk of deep discharge, over charging and overheating are avoided. Also, prevent unwanted balancing of currents by regulating the charging and discharging processes inside the module.
2. Perform Diagnosis - Monitors cell-to-cell variations over time; diagnoses errors, detect safety risks, and sends warning signals to the driver (which can then initiate the proper measure to avoid this safety risk).
3. Collect and Store Data -Records the pack's and the individual's cell signals; stores data related to the battery's life cycle history.
4. Estimate Parameters - Determines cell and pack levels such as State of Charge (SOC) and State of Health (SOH); communicates with controllers for cell balancing.

Each BESS container/housing must act as an independent unit and must include a dedicated Battery Management System (BMS) designed to manage all internal bank functions and internal protection. The system must be designed to interface and communicate with the corresponding PCS control system, the Energy Management System. The PCMS shall be able to grasp the accurate status of the Battery State of Charge (SOC) to manage and operate BESS adequately to set the Upper Limit (UL) and Lower Limit (LL) of the storage amount of the storage battery for the time. The battery management system shall be capable of monitoring voltage and cell temperature at the cell level and it will monitor voltage, current and temperature at the system level. The BMS will

automatically calculate the battery state of charge (SOC) and battery state of health (SOH). The Contractor shall state how the BMS estimates the SOC, and how the SOC measurement system calibrates itself and if any external periodic intervention is required by NEA.

The BMS must protect the battery from operating outside of its safe operating area. Operating limits are to be coordinated with the PCS and EMS. The BMS shall be capable of automated balancing of the battery cells. The Contractor shall provide technical details on the cell balancing strategy. If cell balancing is done during operation, the Contractor shall provide details on the impact of balancing on operation, cell life and auxiliary power demand. If cell balancing requires the system to be offline the Contractor shall provide details on the frequency at which cell balancing is required, based on the duty cycle, the duration of the balancing process, and the impacts on cell life. Automated cell balancing, while the battery operates, is the required cell balancing strategy. The BMS shall alert on failed or inadequately performing cells, when preventative maintenance should be performed, or when the system is in danger of failing to meet specified performance levels or when potential safety hazards exist. The BMS is required to accurately track the battery State of Charge to within 3% of actual available energy and provide feedback to the supervisory control system. The State of Charge must be traceable for full range of power operation and must also account for self-discharge losses as the BESS may be sitting idle for long time periods.

Furthermore, for cooling no fans shall be used. Natural convection to be used to regulate temperature for less noise. Also, the Contractor shall state how the BMS estimates the SOC, and how the SOC measurement system calibrates itself and if any external periodic intervention is required by the employer.

Moreover, following parameters shall be accurately reported as they shall be used for real time decision-making:

- Voltage at the DC Bus and individual cells.
- Temperature, for enclosure and individual cells.
- Current, by unit battery and individual cells.
- Faults and alarm management including ability to acknowledge and reset.
- Real time State of Charge (SOC) values, by unit battery and individual cells considering the aging, temperature, voltage and current.
- Real time discharge and charge kW limits and any deviation from rated value.
- Battery State of Health (SOH) monitoring as defined by the Contractor.
- Charge balancing among cells and strings.

The following protection shall be provided by the BMS:

- Overcharge (Cell level and system level)
- Over discharge (cell level and system level)
- Over temperature (cell level)
- Over current
- Short circuit
- Cell unbalance

3.3.2 **Power Conditioning System (PCS)**

The PCS shall synchronize with the LV grid network before the connection is established. The applicable detailed specifications of the PCS are mentioned below:

Item	Specification
Type	Indoor self–standing type (Installation inside BESS container)
Quantity	One (1) set per site to complete the work
Minimum Rated Capacity	(1) 1000 kW for Gamgadi, Mugu site (2) 2000 kW for Jumla site (3) 1000 kW for Dolpa site (4) 2000 kW for Humla site
Overloading capacity	110% for 60 minimum seconds
Input	DC input shall be specified by contractor/manufacturer
Output	AC 400 V (±10%), 3 Phase 4Wire, 50Hz
Max. Operating altitude without derating	3000 m
Protection Degree	IP 65
Rated Efficiency	Over 95%
Function	1) Grid forming and synchronise with hydro power generators 2) Act as inverter and charger to batteries (bidirectional) 3) Maximum utilization of PV power 4) Peak power management 5) Voltage and Frequency regulation 6) Battery efficient charge/discharge capability 7) PCMS command-controlled start/stop and soft start
Protections	The protection relays for AC system and DC system (Battery) side. The protection relays shall be possible to adjust at variable ranges and all setting shall be possible to adjust at site. 1) Over Voltage Relay (OVR) 2) Under Voltage Relay (UVR) 3) Over Frequency Relay (OFR) 4) Under Frequency Relay (UFR) 5) Inbuilt Surge Protection Device (Type 1 +II) in both AC side and DC side 6) Islanding Operation protection (Both passive and active method) 7) LVRT, HVRT (FRT) 8) Black start capability 9) The Power Conditioning System shall be able to operate the active power control. 10) DC overcurrent protection

	11) DC reverse connection protection 12) Grounding protection 13) Over temperature protection 14) AC over/under voltage protection 15) AC over current protection 16) AC reverse phase sequence protection 17) Surge protection 18) Abnormal auxiliary power supply warning 19) Insulation Resistance Detection 20) Residual Current Protection
Harmonics and Waveform Distortion	The harmonic distortion for single unit shall be 3% or less
Communication	Local monitoring/display via app/web, built in data logger for at least 2 years data collection, emergency power off and field bus communication
Warranty	Power Conditioning System (PCS) and its associated electrical and electronics items shall have a warranty of minimum 5 years from the date of commissioning. The warranty will cover defects and/or failures due to manufacturing defects and/or failures due to materials and non-conformity to specifications and national grid codes due to faulty manufacturing and/or inspection processes at no extra cost to the employer.

3.3.2.1 *Standard for PCS*

The following code and standards shall be applicable to the project as shown below:

Standard	**Description**
IEC 62040-1 or IEC 62477-1	General and safety requirement
IEEE 1547	Standard for interconnection to grid
IEC 61683	Procedure for measuring efficiency
IEC 60068-2 (1,2,14,30)	Environmental testing
IEC 61000-4-2,3,4,6,& 8	EMC
IEEE 519	Harmonics
CEA, IEC 62910	LVRT and HVRT
IEC 60529	IP Test

3.3.3 **BESS Housing**

The battery shall preferably be installed in an ISO container next to the control room where the power system main panel and PCMS are located. A pre-wired ISO-Container shall be provided for battery housing.

The following specifications have to comply:

- It shall be equipped with a redundant inverter air conditioning system, where a failure of one system will not lead to a complete failure of the system. Any failure in the air conditioning system must be communicated to the operator via a control system.
- Customized Containers shall be positioned in a way that they don't cause shadowing on PV modules at any time. They must have ISO 9001 certificate. They must comply with ISO guidelines such as ISO 830 (definitions & terminologies), ISO 6346 (classification codes & markings), ISO 1161 (corner castings), ISO 668 (dimensions & ratings), ISO 1496 (specifications & testing procedures).
- The ambient battery temperature and surrounding air humidity shall always be kept within the BESS manufacturer's specifications.
- For maximum cooling efficiency, the container must have thermal insulation on walls, ceiling and floor.
- The BESS shall comprise of one or more weather-proof insulated containers that completely house all components. The enclosure of each container shall be rated to IP 55, free-standing with lockable fire rated hinged doors. The equipment within the container shall be enclosed in NEMA 1 or better painted steel enclosures.
- The containers shall be installed under a canopy.
- The housing shall have a closed concept, where no permanent airflow is allowed from outside the housing into the housing.
- A fire & smoke detection system shall be installed in the container of the system. In case of fire, a visual and audible alarm has to be activated. In addition, the fire system shall be wired to the PCS system to trip AC and DC breakers. The alarm shall be sufficient to be heard in other containers within the system. The fire protection system shall be equipped with a UPS system to ensure functionality even in case of grid failures. When the smoke detection sensor detects an abnormality, it shall send a signal to alarm.
- The fire alarm system shall include the fire control panel, smoke detector, heat detector, fire alarm bell, and fire alarm horn strobe. The automatic fire extinguishing system uses the total flooding extinguishing mode and includes the fire control panel, manual emergency start/abort switch, fire control pipes (pipelines and high-pressure hose) and nozzle.
- Calculations of flow and hole sizes in pipe network. Sampling unit shall be of LED technology. Detected smoke density shall be able to be adjusted between high sensitivity to equal as ordinary smoke detector. Sampling system shall be connected to loop for ordinary fire alarm via address unit. Operation of sampling unit and status shall be able to display in fire alarm central unit.
- Rodent Repellent system – with Master Console panel including support bracket with SITC of Transducer capable of Emitting Ultrasonic sound of frequencies 20 Khz and higher, with blinking LED Indication & shall be capable to cover area of 150 Sq ft. in floor & ceiling void and 300 Sq. ft. in Room void. Appropriate Rodent Cable and 25" PVC conduit including all accessories.
- HVAC system – (a) Direct Expansion based In- room cooling system is for Racks in battery room (b) Refrigerant pipes, pipe for dehumidifier water should be considered. (c) Containment housing with sliding doors on both sides of the aisle. (d) Providing Linear grilles and diffusers in the non-technical area. The cooling system adapts air-cooled in-room A/C, N+1 redundancy for battery room. A/C shall be equipped with high efficiency variable frequency compressor.
- Racks - Hot aisle containment with skylights and accessories, Sliding doors and access control for containment.

- An intelligent lighting system is installed in the BESS room, corridor aisle and other areas. The lights shall be controlled thru. Motion sensors and turn off / on when there is no occupancy / when there are people.
- Each BESS housing shall be separated from each other and from other equipment in accordance with applicable fire protection standards.
- All components of the battery should be designed to prevent the propagation of fire to other components.
- Each BESS housing must be equipped with a flammable gas monitoring and detection system, which can provide information to operators in the event of a thermal runaway.
- Under no circumstances should the battery self-ignite or explode.
- Each BESS housing must have the ability to vent flammable gases safely if detected within the housing through a remote or automated operation method.
- Contractors should provide technical details on its fire detection, fire protection and fire suppression systems (FM -200/Novec 1230) in the container.
- Contractor shall provide the results of cell level, module level, and unit level fire testing conducted by an ISO certified laboratory. Laboratory test results must be certified, signed and dated by the laboratory.
- Hard-wired Emergency Stop capabilities must be designed into the system for each housing. The push-button shall be suitably protected to prevent accidental operation. This push-button hardwired action shall de-energize and safely shutdown the system in coordination with the PCS equipment.
- The fire and gas protection shall be tested after installation and documented in accordance with applicable standards.
- If the BESS is located in the same housing as the PCS, there shall be a fire wall separating the two sections. Also, the containers shall be with appropriate Venting pipe, heat sound insulation and Concrete flooring. Further, the dimensions/layout should be customized dimension for containers as per site and transportation conditions.
- Temperature control shall be by combination of HVAC and BMS
- The system shall audibly alarm and automatically shut-down the BESS upon detection of smoke/heat.
- Battery Rack Controller with a Max. Efficiency of at least 99% and a Protection Degree of IP 66
- The BESS must establish an early monitoring and warning system for battery abnormalities. The energy storage system must have safety monitoring functions such as internal short circuit detection and fault diagnosis and warning.
- The port of the battery module must be protected when the battery module is not powered on, such as installation, maintenance, and standby, to avoid electric shock during maintenance.
- The BESS must have a complete active and passive security solution, including cell level, module level, battery level, and system level. The implementation mode must be described in detail.
- The BESS solution shall solve the module series mismatch in the battery, isolate faulty modules separately, and improve the system installation and maintenance security and maintainability. The detailed architecture solution and implementation mode must be provided, and the function must be tested during inspection at factory.

- The container shall be secured to the concrete foundation using expansion bolts, thus preventing the container from horizontal vibration.
- The container shall be sealed on the foundation by cable inlet and fire-stop putty to ensure water resistance.
- The container should ensure anti-corrosion and fully welded to ensure waterproof.
- The container door should be waterproof and dustproof, all devices shall be able to be removed without removing the door.
- Ventilation System - optimal cooling design: no air-cross convection. The room to be equipped with heat exchanger for heat dissipation.
- Lighting System - with internal light system shall include a general lighting system designed with ceiling LED lamps (IP20).
- All containers must be properly cladded by Aluminium Composite Panel and a NEA logo shall be inserted.
- Containers must have vinyl false flooring, anti-static flooring (IEC 61340), electrical fitments, ventilation, windows, fire rated doors etc.
- General specifications of container cabins: (These are the minimum requirements; the contractor may provide better equipment than the one stated below without any additional cost to the employer)

#	Description	Specification
1	Construction Type	Prefabricated TEU based shipping / customized container cabin/s
2	Material used	Galvanized steel, Aluminium, Stainless Steel
3	Walls	Steel sheets or thick sandwich panel
4	Roof	Purlin beam + Metal sheets + Insulation (thick sandwich panel) + PVC false roof
5	Floor	Purlin Beam + Metal sheet + Insulation + Cement fibre board + false floor (vinyl, tiles etc.). The containers must be provided with anti-static flooring in all areas where electrical instruments will be housed.
6	Ventilation	The control rooms must have appropriate ventilation
7	HVAC	Yes. The control room must be equipped with temperature regulating HVAC
8	Fire Detection & Protection System	Yes. The container must be equipped with fire alarms and other auto detection mechanisms
9	Others	Electrical systems, bolts & screws, external hook-ups must be as per requirements in accordance with international standards
10	Wind resistance	Resistant to wind speeds prevalent in the areas.
11	Door	Opening fire rated doors for easy ingress.

Other Specifications for the containerized room shall be as follows:

#	Description	Specification
1	Humidity Range	5%-95% RH
2	Operating Temperature	-20^{o}C to +30^{o}C
3	IP Rating	55 (min)
4	Anti-Wind	Wind Speed ≤ 40m/s
5	Service Life	25 years
6	Input voltage range	380/400/415V +/- 15% (for 415, positive tolerance is 10%
7	Cable Routing	Cables cab be routed from the bottom or end

8	Temperature control range	17 – 32°C

3.3.3.1 Thermal Management System

- Each BESS housing must include a thermal management system required to regulate the environment around the batteries for appropriate exterior ambient air temperature, for operations. Temperature, humidity and other atmospheric characteristics are to be controlled within the safe operating range of the BESS, and within the range where the battery life is maximum.
- The thermal management system will include insulation in the walls, roof, and floor of the housing, as well as an automatically controlled HVAC system for all housings.
- The BESS shall be able to maintain temperature in the event of failure of the PCMS or PCS.
- The Contractor shall indicate the behaviour of the system upon partial or complete loss of cooling or heating. The BESS shall be self-protecting against failure of the heating or cooling system and temperature rise or fall. The BESS and battery cells shall survive upon complete loss of cooling system that will bring the temperature inside the housing to the ambient temperature outside the container (an extreme of -15 to +30 degrees Celsius).
- The thermal management system shall be powered by an auxiliary electrical supply over the full temperature range. Alternate external heat sources are not available and combustible energy sources will not be accepted. The Contractor is to state the max amperage requirements of the electrical supply voltage for thermal management system and the power consumption of the thermal management system under the range of design ambient temperature for operation at full load and no load (idling).
- The thermal management system status shall be reported to BESS control system and available for monitoring by the PCMS.

3.3.4 **Recycling Certificate**

When the battery has achieved its end of life it must enter in a recycling program from the Manufacturer. The transport and shipment costs will be carried by the Contractor. The contractor shall provide a certificate proving that the Manufacturer agrees to receive and recycle the lithium-ion batteries according to international applicable standards.

3.3.5 **FAT for BESS**

The Contractor shall develop and submit to the Employer for its review and approval a comprehensive FAT plan that shall demonstrate that the BESS will meet the requirements of the specification. The Employer shall have the right to request reasonable changes to the test plan.

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

After the Contractor determines that the BESS is fully operational, the Contractor shall conduct a FAT, witnessed by the Employer and/or the Employer's representative. The FAT shall consist of

the Contractor demonstrating to the Employer that the BESS is fully operational and performs as specified.

This includes but is not limited to the following:

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

During the FAT, the BESS shall meet the following:

- Be operated and function as specified and designed in all the operating states, use cases, and duty cycles specified herein
- Meet the power and energy requirements specified herein
- Be demonstrated to meet the safety and response to catastrophic failure requirements specified herein
- Have the efficiencies, response capabilities, and other features specified herein and/or proposed by the Contractor
- Tests as specified as above in 3.3.3

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

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

The Contractor shall perform any and all system modifications required during start-up and testing. The testing may be suspended as a result of a BESS malfunction and resumed only on rectification of problem items. Such suspension and resumption will occur at the sole discretion of the Employer.

The BESS will not be accepted for shipment until all FATs have been successfully completed. In addition, the Employer will verify that all provisions of the contract have been met, including verification of all required submittals, any spare parts delivery, and any required system modifications.

3.3.6 **Documents to be submitted**

The Contractor shall furnish complete documentation that will be used for determination of contract compliance, as well as O&M of the BESS.

Review and acceptance of submittals shall not encumber the Employer with responsibility for the adequacy or safety of the Contractor's design.

Titles shall clearly indicate the function of the document, the Employer and location of the facility.

At a minimum, Contractor's documentation shall consist of the following:

- Construction and installation drawings
- Construction materials submittal
- Equipment drawings and specifications
- Operation and maintenance manual
- Maintenance schedule
- Critical path method project schedule
- Master test plan and procedures
- Quality assurance manual
- Software documentation
- Study reports
- Test reports
- Training manual

3.3.7 **Control and Communication**

Control System General Requirements

The control system shall be designed to provide for automatic, unattended operation. The control system design shall provide for local manual operation and remote operation or dispatch from a remotely located computer. The control system shall be programmable for establishing or adjusting all parameters, set points, algorithms, limits, and so on that are required for effective operation as described in this specification. The control system shall be designed to prevent externally supplied, control panel or local signals from causing the BESS to operate in an unsafe manner or in a manner that may damage the BESS.

Control Functions and Protocols

- To the extent possible, all BESS control functions and operating modes shall be in accordance with standard functionalities for smart distributed resources, as documented in the IEC 61850-90-7.
- The communication protocol for the BESS shall be according to IEEE 1815-2010- Standard for Electric Power Communications—Distributed Network Protocol (DNP3) or IEC 61850.

- If data points and/or control functions outside the standard point definitions in DNP3 AN2011-001/IEC 61850 are created by the Contractor, the Contractor shall maintain a systematic log of the same for the purpose of maintaining/facilitating interoperability with future standards/protocols for distributed energy resources

Additional Control System Functions

<u>Shutdown/Startup/Standby</u>

The start and stop controls shall be as per DNP3 AN2011-001 standard specifications or IEC 61850. The control system shall use these controls for an orderly and safe shutdown, even in the absence of grid power. The control system shall also use these controls for an orderly startup sequence, which shall provide for a safe system reset from any standby or operating condition so that the unit goes through a normal startup sequence in the same way it would when being powered up after loss of power or being in a shutdown state. The control system shall include provisions for a standby state (that is, BESS available but not charging or discharging), which shall be the end result of a normal startup sequence. It shall also be possible to enter the standby state from any of the other operating states except connect/disconnect.

Initiation of Shutdown

The control system shall initiate shutdown under the following conditions and shall remain in the shutdown state until a reset signal, either local or remote, is initiated.

- An appropriate alarm shall be set.
- Emergency trip switch.
- Loss of the low-voltage AC or utility grid voltage.
- An AC circuit breaker trip (either side of transformer).
- Door interlock: Initiate shutdown when the door is opened (with appropriate provision for maintenance work). Interlocks shall be self-resetting.
- Smoke/fire alarm.
- Control logic trouble.
- A DC ground fault (field-adjustable setting).
- Remote disable (no reset required).
- Grid system faults (balanced and unbalanced; line-to-ground, line-to-line, and three-phase).
- Abnormal frequency
- Abnormal voltage
- Islanding condition.
- Protection or control scheme failures, including the following:
- Failure of local interconnection protection system
- Failure of critical breaker trip coil or interrupting device
- Loss of DC supply

Reset Alarms

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

Event/History Logging

The control system shall provide for the automatic logging of the following information:

- All errors or failures
- All startup and shutdown actions
- All control actions
- All responses to control actions
- All limit violations, including returns within limits

Status Reporting

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

Time Synchronization

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

Change Operational Mode

The control system shall support activating/deactivating control functions. The control functions are expected to be executed by command from a remote host but may also be scheduled.

Perform Self Diagnostics

The control system shall provide for self-diagnostic functions.

Control System Hardware Requirements

All local control and monitoring system components shall be housed in appropriate controlled environment enclosures either as separate arrangement or in conjunction with Solar Plant SCADA system.

Control System Self-Protection and Self-Diagnostic Features

The BESS shall include appropriate self-protective and self-diagnostic features to protect itself and the battery from damage in the event of BESS component failure or from parameters beyond the BESS's safe operating range due to internal or external causes. The self-protective features shall not allow local or remote signals to cause the BESS to be operated in a manner that may be unsafe or damaging to the BESS. All protective operations resulting in a shutdown shall be carried out in an orderly and safe manner, even in the absence of utility power.

Temperature sensors shall be incorporated in critical components within the BESS. The BESS shall alarm and go to standby/fault mode when an over-temperature condition is detected.

The BESS shall alarm upon detection of a DC ground fault. The alarm trip level shall be field adjustable.

Door interlock switches shall be provided for all BESS container doors. The BESS shall alarm and go to shutdown mode when a BESS door is opened. Doors shall be fitted with provisions for external locks.

The BESS shall alarm and go to shutdown mode upon detection of smoke.

Surge-protection devices shall be provided at the input and output terminals of the BESS.

Control Panel

The BESS shall include a local control panel or console, which is easily accessible, on or within the BESS container. As a minimum, the following operator controls shall be located on the control panel:

- Trip/reset for the BESS AC circuit breaker or contactor.
- Trip/reset for DC circuit breaker(s)/contactor(s).
- PCS on/off.

- Reset toggle or push button. When reset is initiated, the control system shall resume control and proceed to the appropriate operating mode.
- Reset cut-out selector switch to disable remote or local reset signals.
- A selector switch to manually set the operating state (that is, the shutdown, disconnect, or operate state) and to have the control system set the operating state automatically.
- A selector switch to manually set the operating mode and to have the control system set the operating mode automatically.
- The control panel or console shall also include meters, indicators, and displays.

Performance Monitoring and Data Acquisition

The BESS shall include a (Data Acquisition System) DAS to provide continuous monitoring and display of key operational parameters, as well as permanent archival of all measured parameters. The DAS shall include sensors, transducers, wiring, signal isolation and conditioning circuitry, and data acquisition and analysis hardware and software as required to perform the functions described in this section. The DAS shall be of standard commercial manufacture and shall use hardened components suitable for operation in the climatic conditions prevailing at site.

The DAS shall measure operational data, as described in this Clause, and shall record all data points to fixed and removable non-volatile memory. The DAS shall be capable of making all monitored data and events available through the DNP3 / IEC 61850 communication interface and shall permit display of current values and recent historical trends on a local screen for all recorded points. In addition, the DAS shall provide panel meter displays of certain operational parameters, as prescribed below.

Provision of monitoring and event data via the communication interface shall adhere to DNP3 AN2011-001 / IEC 61850 to the extent possible and capture at least the following data points:

- Frequency at the AC bus
- AC real power
- Power factor
- Real energy delivered
- Real energy received
- Auxiliary power
- Auxiliary energy
- DC power
- DC voltage
- DC current
- Phase A voltage
- Phase A angle
- Phase B voltage
- Phase B angle
- Phase C voltage
- Phase C angle
- Battery state of charge
- Battery string currents
- Battery temperature

Digital displays, on the BESS Control Panel, shall update at least once per second. The DAS shall be integrated with the Solar PV SCADA described elsewhere in this Technical Specification either as addendum or within an overall Energy Management System Interface. The DAS shall, at a minimum, provide remote data inquiry from personal computer– based platforms and data file export capabilities in ASCII format on independent media (such as a universal serial bus drive) that are readable on personal computer-based systems.

The DAS shall continuously measure or calculate the data points identified in Clause above and shall make them available via the communication network as specified. All measured parameters shall also be permanently archived in all modes of operation. For continuously varying quantities, the Contractor shall propose for Employer's review and approval an approach to data archiving that is suitable for each quantity measured. The final approach will be decided during product design.

The DAS shall provide unsolicited message capability for reporting critical alarms. The Contractor and the Employer will agree on a list of alarms that are reported the instant they are detected. However, a minimum of following parameters shall be displayed on BESS local control panel, console, or SCADA computer:

- Main temperature Alarm (on system temperature exceeding a predetermined threshold)
- Smoke/fire Alarm (on system detection of smoke/fire)
- DC leakage current (battery leakage current to ground exceeding a predetermined threshold)
- Breaker status (connect/disconnect switch)
- AC voltage OK (system ac voltage exceeding a predetermined threshold)
- Battery temperature alarm (battery temperature exceeding a predetermined threshold)
- Synchronization error shutdown
- PCS fault
- Weak Unit Battery Alarm
- AC system fault
- Control logic problem (problem with the BESS control logic)
- DC fuse blown
- Container door open (BESS container door opening)

The BESS shall include provisions for determining and storing in non-volatile memory the sequence of abnormal events, trips, and/or alarms that cause the BESS to go to disconnect or shutdown state. It is preferable that this function be implemented separately from the normal operations data acquisition function of the DAS so that failures in the latter (hardware/software failures or power interruptions) will not prevent the permanent logging of abnormal event sequences. The BESS shall include provisions to transmit, at a minimum, the data displayed on the panel meters and the alarm/status indicators to the remote computer.

3.3.8 **Other Design Requirements**

Noise Levels

The Contractor shall provide for and maintain noise mitigation devices like Noise mufflers at site, if required. The contractor must also ensure noise level <1dB at 1m distance. The contractor should use natural convection for cooling to reduce noise levels.

Fire Protection

The Contractor shall design and install a fire protection system that conforms to good engineering practice, as per prevailing guidelines in Nepal and considering thermal runaway fire characteristics of the Battery Unit/ Packs provided by the OEM.

The fire protection system design and associated alarms shall take into account that the BESS will be unattended. If required by the type of fire protection system provided, the Contractor shall calculate and take into account the heat content of the battery cell materials in designing an appropriate fire protection system. Separate fire protection systems may be used in the battery, PCS, and control areas.

Toxic Materials
If any toxic substance can be emitted from the equipment during a failure, fire, or emergency or protective operation, description of the toxic nature of the substances as well as treatment for exposure to it shall be included in the O&M manual. Their treatment and disposal shall be in accordance with Hazardous Waste Management Rules of Government of Nepal.

3.3.9 **Warranty**

The Contractor shall provide a warranty for the entire BESS and its constituent equipment.

At a minimum, the Contractor shall provide an unconditional, 8 (eight) -year parts and labour warranty on all BESS equipment except battery (unit or racks). For the battery storage, the warranty shall cover parts warranty including battery nominal capacity ratings in order to meet the End of battery Life condition described in this specification.

Warranty replacement shall be required for individual unit batteries that degrade in performance to the point at which the BESS cannot meet the requirements specified in this specification up to the End of Battery Life and/or for unit batteries that materially degrade the availability, reliability, safety, or functionality of the BESS.

The warranty shall guarantee the availability of battery replacements delivered to the site during the battery warranty period. This period, shall, however, not be considered part of the Accountable Outage period for assessing BESS availability.

Additional warranty requirements are as follows:

- The warranty shall specify the terms and conditions of the warranty, including operating conditions requirements, procedures that must be followed, and all maintenance requirements. The warranty terms shall be easy to understand and clearly stated.
- The warranty shall provide an explicit statement as to the warranted cycle life and the warranted calendar life of the battery.
- The warranty shall include a simple and easy to understand proration formula, if any, to be used in crediting the Employer for unused life or capacity of equipment replaced or repaired.
- The warranty shall specify the scope of service associated with software updates, cost of which will be borne by the contractor.
- The warranty shall specify the scope of service included in replacement or repair of the equipment.
- The warranty shall specify the estimated time to complete the repairs/replacement required to restore the BESS to the warranted performance level. The time shall be given as the number of

working days from the time of Employer's notice to the Contractor that the BESS has failed to meet the performance requirements.

If BESS availability falls below the levels guaranteed by the contractor, in bidding form FUNC under section 4 bidding forms of vol 1, due to the days taken for repair and maintenance of BESS under warranty, then the contractor will be liable to pay liquidated damages as mentioned in section 3.12.1.

Data Sheet for Battery

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
1	**General**				
1.1	Manufacturer				
1.2	Battery chemistry (active material)				
1.3	Battery type (cylindrical, prismatic, etc.)				
1.4	Enclosure Specifications (indoor, IP-class)		Indoor		
1.5	Min / Max operation temperature	°C	-20° / ≥ +35°		
1.6	Special conditions		Heavy snowfall, high humidity		
1.7	Max. relative humidity	%	>95		
1.8	Calendar lifetime	Years	>20		
1.9	Cycle lifetime (Full cycles till EOL @ 80% with DOD 80%, 1C/1C at 25°C)	Nr.	6000		
2	**Electrical**				
2.1	Usable capacity @ C-Rate: 1C	kWh			
2.2	Size of smallest unit to be changeable on site	kWh			
2.3	Self-discharge	%/time			
2.4	Cycle efficiency (round trip)	%	>85		
2.5	Maximum DC voltage	V	<1,000		
2.6	Minimum DC Voltage	V			
2.7	Nominal DC current charge	A			
2.8	Nominal DC current discharge	A			
2.9	Maximum DC current charge (for how long?)	A			
2.10	Maximum DC current discharge (for how long?)	A			
2.11	Time limit for max. current	Time			
2.12	Total nominal DC power charge	kW			
2.13	Total nominal DC power discharge	kW			
2.14	Maximum DC power charge (for how long?)	kW			
2.15	Maximum DC power discharge (for how long?)	kW			
2.16	Cooling Technology (air, liquid, etc.) and power/energy used for cooling				
2.17	Height / Width / Depth	mm			
2.18	Weight	kg			
2.19	Number of individual Battery Racks	No.			

Data Sheet for Battery Inverter

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
1	**General**				
1.1	Manufacturer				

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
1.2	Inverter description/technology				
1.3	Environmental conditions description		local conditions must be respected		
1.4	Min / Max operation temperature	°C	-20° / ≥ +35°		
1.5	Location of installation		indoor		
1.6	Special conditions		Heavy snowfall, high humidity		
1.7	Grid building option (standalone operation)				
2	**Electrical**				
2.1	Size of smallest unit (3-Phase)	kW			
2.2	Number of parallel units in system	Nr.			
2.3	Maximum DC voltage	V	<1,000		
2.4	Minimum DC Voltage	V			
2.5	Maximum current AC and DC(short circuit)	A			
2.6	Maximum continuous discharge current	A			
2.7	Maximum continuous charge current	A			
2.8	Continuous discharge power	kW			
2.9	Continuous charge power	kW			
2.11	Maximum efficiency and efficiency @ 100%/75%/50%/25% of rated power	%	>96		
2.12	Cooling Technology (air, liquid, etc.) and power/energy used				
2.13	Maximum AC current (short circuit)	A			
2.14	Nominal AC current	A			
2.15	Nominal AC voltage	V			
	AC Isolated grid frequency	Hz	50		
2.16	Power factors (grid connected)		Minimum 0.80 lagging, 0.80 leading		
2.17	Power factors (grid building, island operation)		0-1 lagging, 0-1 leading		
2.18	Maximum THD	%	<3		
2.19	Operation consumption	W			
2.20	Standby consumption	W			
2.21	Auxiliary power voltage	V			
2.22	Protection class (EN 60529)				
2.23	Protection class (EN 60721-3)				
2.24	Height / Width / Depth	mm			
2.25	Weight	kg			
3	**Grid Connection Requirements**				
3.1	Frequency measurement average	ms	<20		
4	**Interfaces**				
4.1	Communication protocol		Modbus/Mbus, RS485		

3.4 Hydropower generator synchronization

The Solar PV + BESS plant has to be designed with a provision for future synchronization with mini hydro power plants in the area as per grid code.

Provision for communication between hydropower generator controllers and PCMS shall be provided via appropriate communication mode.

3.5 Electrical and power system requirements

3.5.1 Power system and grid interface

The electrical power system of the solar PV power plant will be designed to meet the requirements of the export of power to the NEA grid. The DC electric power generated by the PV arrays and BESS will be converted into 400V, 3 phase, 50Hz, stepped up to 11 kV through a power transformer. The power from the plant will be fed to an 11 kV transmission line passing through the site with its associated switchgear. The tapping can be done by Loop-In-Loop-Out (LILO) arrangement by providing slack jumpers with the existing transmission line. An AC bus coupler will be used to connect and disconnect the system to facilitate standalone operation when grid power is not available.

3.5.2 LV power interfacing panel

Output from all PV inverters and grid forming bi-directional battery inverter will be combined in an AC bus in LV panel. The output from the LV panel which shall be containerized will be primary input to the 0.4/11 kV transformer. The LV panel shall be fitted with suitable rating & size copper bus, circuit breaker, isolator indicators for all incomer and outgoing terminals. Nut & bolts including metallic cubicle shall have to be adequately protected from corrosion. The overall dimension shall be fitted with other Inverters/ Power Conditioning Units of the Power Plant. However, dimension, weight, sheet thickness, painting etc., should be indicated by the Contractor. The bill of material associated with the equipment should be clearly indicated while delivering the equipment.

3.5.3 Power transformer and switchgear

The power transformer should have:

- Appropriate cooling design
- Transformer load losses - <1% and no-load losses - < 0.1% KW
- Degree of Protection - IP 54
- With auxiliary Transformer 25 kVA Dyn 11 with load loss < 1% and no-load loss < 0.1%
- Transformer monitoring and protection - Oil level, oil temperature, oil pressure, Buchholz, differential Protection and OC and EF protection
- MV surge arrestor
- Warranty power transformer shall be 5 years
- Seismic level 9. Seismic loads can be 0.3g horizontal acceleration and 0.15g vertical acceleration.
- The emergency stop button to stop ACB in the LV panel and VCB in switchgear in case of emergency for higher O&M safety.
- The power transformer shall be secured to concrete foundation.
- The container should ensure anti-corrosion and fully welded to ensure waterproof.
- Transformer accessories: LV bushings: 3 pcs, MV bushings: 3 pcs, MV connectors: 3 pcs, off-load tap changer of ±10% @2.5% each step: 1 pcs, Buchholz relay: 1 pcs, Oil temperature indicator: 1 pcs, Pressure relief valve: 1 pcs, Oil level gauge: 1 pcs, Dehydrating breather: 1 pcs, Oil filling/ drain valve: 1 pcs, Earthing terminal: 1 pcs and other required accessories to complete.
- Incoming: The transformer shall connect to LV room by copper busbar through the side of the transformer.

- Outgoing: The transformer shall connect with the MV room by single core MV cable through the side of the transformer. Cable connection of transformer to switchgear shall be copper core cable.
- Concrete Oil tray to be constructed and shall be used to receive the insulating oil of transformer in case of leakage, the volume of the oil tray shall be 120% of the transformer oil volume. The cost for concrete works shall be paid as per quoted civil rates.
- Rated Peak Withstand Current 50 kA
- Rated Short time Withstand current 25 kA / 1s
- Auxiliary Distribution Board equipped inside for the auxiliary power supply.
- All the internal cabling within to be prefabricated and pretested at the factory, including busbar between LV panel and transformer, MV cable between transformer and switchgear, communication cable and grounding cables. No further cabling work for internal connection to be needed.

General specifications of transformer

1) Rated capacity:

S. No.	Location	Capacity
1.	Jumla	3000 kVA
2.	Gamgadi, Mugu	2000 kVA
3.	Simikot, Humla	3000 kVA
4.	Dolpa	2000 kVA

2) Service & Duty: Continuous, Inverter duty Transformer
3) Type: Core Type
4) Location: Outside
5) Standard: IEC 60076-1:2011, IEC 62271-200, IEC 62271-202, EN 50588-1, IEC 61439-1 and IEC 60296:2020
6) Type of Cooling: ONAN
7) Wound: Copper Double Wound
8) Rated input voltage: 400 V (+/-) 5%
9) Rate output Voltage: 11000 V
10) Highest system voltage: 12000 V
11) Number of Phases: 3 (three)
12) Frequency: 50 Hz
13) Voltage variation: (+/-) 10%
14) Frequency Variation: (+/-) 3%
15) Combined Voltage and Frequency variation: (+/-) 10%
16) Winding: HV winding DELTA; LV winding STAR
17) Taping Range: ±10.0% in steps of 2.5 %
18) Vector Symbol: Dyn11
19) No Load Current: Less than 2% of full load current
20) Differential protection, Overcurrent and Earth fault protection.

For each site at Jumla and Humla one 3000 kVA and for Mugu and Dolpa one each of 2000 MVA, 0.4/11 kV, 50 Hz, and 3-phase transformer shall be provided to step up the generated voltage to 11 kV. The step-up transformer will be designed and manufactured as per IEC 60076-1: 2011 and will be supplied with the first filling of oil in accordance with IEC 60296: 2020. Transformers should have all necessary protection features like silica gel breather, Buchholz relay, pressure relief de-

vice, magnetic oil level gauge, oil temperature indicator and winding temperature indicator. Documents/drawings such as technical datasheets and earthing design calculations must be submitted and get approved by the employer prior to supply.

Transformers and allied accessories shall comply with the requirements of the latest editions of IEC. Standards and Regulations applicable in the area where equipment is to be installed shall also be followed. Table below indicates a non-exhaustive list of standards to which all the transformer should conform.

IEC-60076	Power Transformers
IEC 60137	Insulating bushings for alternating voltages above 1 kV
IEC 60156	Insulating liquids - Determination of the breakdown voltage at power frequency- test method
IEC 60296	Specification for unused mineral insulating oils for transformers and
IEC 60551	Determination of transformer and reactor sound levels
IEC 60616	Terminal and tapping markings for power transformer
IEC 60722	Guide to the lightning impulse and switching impulse testing of power transformers and reactors

Construction

Tank

- Tank should provide rigidity and dynamic ability to withstand pressure due to short circuit current. It should be capable of bearing all stresses during transportation and operation without any deformation.
- Low carbon steel grade plates that have been stiffened and reinforced may be used. Oil tight welds and joints shall be provided and measures should be taken to prevent internal corrosion of plates.
- Inspection opening and cover must be provided with handling equipment for easy access to bushing connections.
- The cover design shall avoid stagnant water and facilitate easy flow of gas bubbles towards the Buchholz relay.

Magnetic Circuit

- Design of magnetic shall be such as to avoid static discharge development of short circuit within itself or in earthed clamped structure.
- Core shall be of non-aging, high grade and low loss cold rolled grain oriented (CRGO) silicon steel.
- Annealing of the laminations in a non-oxidizing atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after cutting and punching operation shall be done.
- To prevent the movement of core and winding during transportation, installation and while in service the core, framework and clamps shall be arranged and tightened to securely hold the laminations.
- Ducts to be provided ensuring adequate cooling and efficient heat transfer.

Winding

- Winding conductor should be electrolytic grade copper, free from scales and burrs.
- To avoid shrinkage during operation, windings shall be subjected to shrinkage treatment.

- The winding assembly should be full vacuum dried and then impregnated immediately in transformer oil.
- Windings and connectors shall be braced to withstand shocks due to rough handling, and forces due to short circuit, switching or other transients.
- Permanent current carrying joints in winding and leads shall be brazed.
- Coils shall be supported at frequent intervals using dried and high-pressure compressed wedge type insulation spacers to ensure proper oil circulation.
- Insulating materials shall be compatible with transformer liquid under all service conditions.
- Leads to the terminal board and bushings shall be rigidly supported.

Insulation levels of the transformer windings shall be rated as follows:

Voltage	Impulse Voltage (kV Peak)	Power Frequency Voltage (kV)
Low Voltage	-	3
11000 Volts	75	28

Insulating Oil

- Oil will be pure hydrocarbon mineral oil, clean, free from moisture, and have uniform quality throughout.
- For the first oil filling of each transformer 10% extra oil of total quantity of oil in non - returnable shall be supplied

Radiator

- Sufficient number of radiators shall be made to meet the requirement of temperature rise.
- Radiators shall be detachable type directly mounted or separately mounted.
- Flanged, gasketed and bolted connections shall be used for connecting the radiators to the tank.
- Radiators shall be individually tested for leakage and pressure test etc. before connecting to tank.
- Each radiator shall have top and bottom shut off valves, top filling plug, bottom drain plug, lifting lugs, thermometer pockets at inlet and outlet pipes, air release devices, earthing provisions, filter valves and all other necessary accessories required.
- Radiator valves must indicate open and close direction clearly.

Marshalling Box

- Marshalling box fabricated using cold rolled sheet of at least 1.6 mm thickness shall be tank mounted, with a sloping roof. The box shall be tank protection of IP-55.
- All the incoming cables shall enter the marshalling box from bottom.
- All outgoing connections from the transformer shall be connected to the marshalling box. It shall be enclosed in a metal casing and be weather and dust proof with a minimum of IP 55 certification.
- The temperature indicators shall be mounted at about 1600 mm from ground level.
- The marshalling box shall have necessary accessories such as locks, glands, glass doors, terminal boards and all other appropriate equipment as required.

Conservator and Breather

- Conservator with oil level gauge and plain silica gel breathing device shall be mounted integral with the tank in such a manner that the lowest oil level bushings remain under the head of liquid under all times.
- Volume of the conservator shall meet the requirement of expansion of total oil in transformer and cooling equipment from minimum ambient to oil temperature of 90 degree C.
- The oil filling hole shall have a cap and suitable drainage valve to completely drain the oil.
- One end of conservator shall be bolted to facilitate cleaning.

- Breathers shall be mounted at approximately 1400 mm above ground level.
- One prismatic type oil indicator should also be provided on the conservator.
- One oil gauge magnetic type with provision for low levels alarm shall be mounted on conservator to indicate the minimum normal and maximum level.

Pressure Release Device

- Pressure release devices operating at a static pressure below the hydraulic pressure of the tank shall be provided at all appropriate locations. The device shall also be equipped with potential free contact for alarm/trip and connected to the marshalling box.
- To avoid discharge spraying from the pressure release devices on the tank, the discharge shall be taken through pipes away from the transformer.

Buchholz Relay

- The relay shall be a double float relay as per IEC with shut off valves on either side.
- Pot cocks at the top and bottom of the relay drain plug. An inspection window and calibrated scale for measurement, terminal box with oil tight double compression type brass gland.

Valves and Connections

- All valves shall be of gun metal only and of sluice type provided with hand wheels. The valves shall have padlocked facility in closed and open condition.
- Open and closed position shall clearly be mentioned on the valves.
- They shall be provided with blanking plates or screwed plugs.

Oil and Winding Temperature Indicator

- 150 mm dial type thermometers and 150 mm diameter dial type indicator shall be provided for oil and winding respectively. Minimum two potential free contacts for alarm and trip signals shall be provided. Temperature sensing equipment shall be connected through capillary tube.
- Temperature indicator dials shall have linear gradations to clearly read at least every 2 degree C with ±1.5% accuracy or better.
- Remote temperature indicator for both oil and winding shall be required.
- The device shall be complete with lamp, sensing element, image coil, calibration device and all other accessories required.

Accessories

- The transformer shall be complete with the following accessories:
- Off load tap changer with position indicator and locking device.
- Oil conservator with sump and drain valve with cover plate.
- Dehydrating breather with silica gel and oil seal.
- Oil filling valve 32 mm with cover plate.
- Thermometer pockets.
- Diagram, rating plate, terminal marking plate.
- Two earthing terminals.
- Lifting lugs for active part only.
- Four bi-directional plain rollers.
- First filling of oil +10% extra at no cost.
- Double diaphragm explosion vent with sight glass.
- Dial type winding temperature indicator with maximum reading pointer and alarm and trip contacts.
- Pocket for above item.
- Oil level gauge with minimum level marking.
- Double float Buchholz relay with testing cocks, alarm and trip contacts.
- Air release plug on tank cover.
- Isolation valve on both sides of buchholz relay.
- Weather Proof thermo junction box.
- 150 mm dial type oil temperature indicator with maximum reading pointer and alarm and

trip contact.
- 150 mm dial magnetic oil level indicator with low level alarm and trip contacts and minimum filling and maximum level markings.
- Base channel with viewing holes.
- Drain cum bottom filter valve 32mm with cover plate.

In addition to the techno commercial offer all the manufacturers shall submit following documents for the transformer proposed:
- General Arrangement drawing of the transformer, showing front view, plans, foundation plans, bushing details, termination details and elevations, transport sections and weights.
- Manufacturer / Supplier / Contractor shall submit type test certificates issued by a International Testing Authority.
- Routine tests at the manufacturer's works in accordance with IEC 60076.
- Calculations to demonstrate the thermal ability of the transformers to withstand short-circuit.

Following are the documents that shall be submitted along with the deliveries:
- Technical literature giving complete information of the components / equipment.
- Erection, Operation and Maintenance Manual complete with all relevant information, drawings and literature for auxiliary equipment and accessories, characteristics curves for relays etc.
- A comprehensive spare parts schedule.

Technical Parameters of LV/MV Transformers

kVA rating	
Rated voltage:	
HV Winding	11 kV
LV Winding	
Rated Frequency	50 Hz. + 3%
Number of phases	3 Phase
Vector Group	
HV Winding	
LV Winding	
Vector Symbol	
Type of construction	
Type of cooling	Oil Natural Air Natural
Tap changing equipment	
Type	Off load type
No. of steps	12
% of voltage at each step	1.25% each
Tap Range %	+ 7.5 % to -7.5 %.
Temperature above ambient of 50°C	
Oil	50 deg C
Winding	55 deg C
Losses at rated voltage on principal tap and rated frequency	

No load loss	
Copper loss at full load at 75°C	
Withstand time for three phase short circuit at terminals (sec.)	
No load current at rated voltage and rated frequency.	
Insulation level	
Separate source power frequency voltage withstand for more than one minute	
HV Winding	
LV Winding	
Full wave lighting impulse stand voltage	
HV Winding	
LV Winding	
Designed magnetic flux density	
% Impedance (±10% tolerance)	
Regulation at full load at 75°C	
At unity power factor	
At 0.9 power factor lag	
At 0.8 power factor lag	
Over fluxing withstand time (sec)	
120 percent	
150 percent	
170 percent	
Efficiency	
Efficiency at unity power factor	
Full Load	
75% Load	
50% Load	
25% Load	
10% Load	
Efficiency at 0.9 power factor	
Full Load	
75% Load	
50% Load	
25% Load	
10% Load	
Efficiency at 0.8 power factor	
Full Load	
75% Load	

50% Load	
25% Load	
10% Load	
Approximate dimensions	
Tank/enclosure L x b x h	
Overall L x b x h	
Approximate weight of transformers	
Core	
Winding HV	
Winding LV	
Insulation	
Enclosure and fittings	
Total weight	
Windings	
Type of windings	
Current Density at rated load	
HV Winding	
LV Winding	
Clearances	
Phase to Phase in air	
Phase to Earth in air	
Creepage distance	
Termination	
Primary Side	
Secondary Side	

Switchyard equipment:

11 kV Isolator with & without Earth Switch:

- The isolators shall be outdoor, electrically and manually operated, horizontal, double break, center rotating type and suitable for mounting on structural members.
- The isolator operating mechanism shall be twist and turn type.
- The isolators shall be designed with suitable short circuit current rating of 25kA for 1 sec. The design shall permit breaking the charging current of 11 kV line.
- The isolators shall be suitable for operated on no load condition. The mechanical and electrical interlocking arrangements shall be made with circuit breaker to prevent the operation of Isolator on load condition.
- Creepage distance for insulators within isolator shall be 25mm/kV.
- Mechanical interlock to be provided with earth switch as applicable.
- Lightning impulse voltage shall be 75 kVp for 11 kV for phase to earth and 75 kVp for 11 kV peak for across the isolating contact.
- Power frequency voltage shall be 28 kVrms for 11 kV for phase to earth and 28 kVrms for 11 kV for across the isolating contact.
- Minimum auxiliary contacts required are 10NO+10NC for main switch and 8NO+8NC for earth switch.
- A mechanized key interlock shall be incorporated for interlocking with associated circuit breaker. The key shall be released only when the isolator is fully closed or fully opened.

Lightning Arrestors:

- The lightning arrestor shall be heavy duty, station class type, discharge Class III, gapless Zinc Oxide type rated for 11 kV and suitable for use in 11 kV solidly earthed neutral system and 10kA current rating.
- The arrestors shall be capable of spark over on severe switching surges and multiple strokes. The lightning arrestors shall be capable off discharging over voltage occurring during switching of unloaded transformers.
- Surge counters shall be furnished with the insulating bases for connection, supporting insulator and necessary hardware.
- No radio interference shall be caused by the arrestors operating at the normal rated voltage.

Current Transformers (CT)

- Current transformers shall be single phase, two limbed, core type, oil immersed, self-cooled outdoor and hermetically sealed, dead tank, hairpin type suitable for use on the stipulated electrical system.
- The primary and secondary windings shall be suitable for continuous loading of 120% of rated current. The burden and accuracy class of the CTs provided shall be adequate for operation on the associated protective device and measuring instruments.
- The voltage produced at the cores by fault current or during transients shall be well below the saturation voltage to ensure good transient response.
- All the current transformers shall be provided with oil level indicator, filling plug, power factor testing terminal, rating and diagram plate.

Potential Transformers (PT)

- The Potential transformers shall have an accuracy class of over 0.2 for metering and class 3P for protection. The Voltage factor for the PTs shall be 1.2 times continuous and 1.5 times for 30 seconds.
- The voltage transformers shall be single phase two limbed core type, oil immersed, self-cooled, outdoor and hermetically sealed, dead tank type, suitable for use on the stipulated electrical system of 11 kV.
- The voltage transformers shall be used for metering, operated as a group of three, star / delta connected on 50 Hz, phase system.
- The bushings and insulators shall have creepage distance of minimum 25mm/kV to suit heavily polluted atmosphere.
- All the potential transformers shall be provided with oil level indicator, filling plug, power factor testing terminal, rating and diagram plate.

Bus bar System

- The bus bar system shall comprise of insulator supports and bus bar sections.
- For interfacing all the equipment with strain insulators with ACSR 'Wolf' conductor shall to be used. Suitable type and number of connectors are to be provided in both the cases.
- Clamps made from aluminum alloy shall be used for end terminations.

Supporting Structures

- The supporting structures shall be provided for insulators, CTs, PTs, Isolators, lightning arrestors etc.
- The structures shall be of bolted type construction and fabricated from GI material.
- The structures shall include towers and beam structures required for 11 kV incoming lines.
- The structure designs shall be made considering the minimum ground clearance of 4.6 meter.
- The structure designs shall be suitable for climatic conditions mentioned in above sections.
- Structure galvanizing shall be carried out by hot dip process. Purity of zinc to be used shall be 99.5%.

Earthing

- Earthing arrangement for the switchyard shall be in accordance to IEEE80.
- The earthing shall essentially include but not be limited to earth electrode and earth connection to lightning arrestors, switchyard equipment, body earthing, transformer neutral earthing and earthing of structures.
- The entire earthing installation shall confirm to IEC and shall be done in accordance with IEEE specifications and standard engineering practices.
- Earthing electrode shall be 40 mm Dia. M.S. Rod and the earth electrode shall be Threaded earth pits 100mm dia, 3m long CI pipe earth electrode underground up to the level of 2.5 mtrs. Earthing terminal shall be complete with watering pipe, funnel screen & earthing bus bars. Earthing pipe buried under ground shall be surrounded by 300 mm thick homogeneous layer of charcoal and salt. Earthing chambers shall be provided with CI covers of size 450mm x 450 mm or with circular cover having 600 mm dia.
- The main earth grid shall be laid at a depth of 1000 mm below Ground level. In case of built-in trenches, earth strip shall be laid along the trench and shall be firmly cleated to the wall or cable supports.
- The electrodes shall be tested for earth resistance by means of standard earth tester.
- A disconnecting facility shall be provided for individual earth pit to check earth resistance.
- Entire earthing system and lighting protection system shall be tested for continuity by earth testing equipment after completion of the installation. Earth resistance value shall be checked and verified. If it is high then corrective measures such as addition of earth pit shall be taken to obtain desired value.

Wiring

- All wiring shall be done with PVC insulated, 650 V grade, single-core multi strands (minimum 3 strands) annealed copper conductors suitable for temperature and humidity specified. The cross sectional of the wires for voltage, current and control circuits shall be 2.5 mm2 and that for the alarm circuits shall be 1.5 mm2, the wires shall be vermin proof and shall be laid in plastic gutters.
- Each wire shall be identified at both ends with wire numbers by means of PVC ferrules. Color coding for the wires shall be as per IEC.
- The bolted type terminals shall be suitable to receive crimped wires to give positive connection. All terminals shall be properly shrouded against accidental contact.

Name and Identity Plates

- All instruments, relays and other electrical devices mounted on the control panel shall be provided with plates bearing the manufacturer's name, serial number and the electrical rating data.
- Plastic plate at least 10 mm wide bearing suitable identification marks shall be fixed in the interior of the switchboard, at the test blocks, at the fuse blocks and the cable terminals. Similar plates shall be fixed to the exterior of the switchboard in appropriate places to indicate the functions of control switches, push buttons, lamp and other equipment not incorporated in the mimic diagram.
- Brass or plastic plates bearing respective circuit designation of 50 mm width etched in 40 mm high letters shall be mounted on the front side and back side of each panel shall be supplied and fixed in such a way that these can be removed and refitted when desired.
- Instrument Tagging: -All equipment shall have a rust proof metal tag permanently attached to it with the tag number.

Auxiliary System

Auxiliary system in Transformer shall include, but not be limited to, the following systems and components:

- auxiliary LV/LV transformers
- LV switchgear
- operational meters for auxiliary loads in transformer station (optional)
- required protection systems
- power and control cables, cable supports
- lighting and emergency lighting systems
- earthing and lightning protection systems, including earthing connections to adjacent earthing grids

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.

Connection of the Delivery Station with 11 kV OHL

Connection from 11 kV switchgear in the Delivery station to the gantry of the overhead line shall be provided by 11 kV cables.

The interface point shall be connection of the 11 kV cable outdoor sealing end (installed on a horizontal platform) and lightning arrester in hanging position to the gantry of the 11 kV overhead line. In addition to the techno commercial offer bidder shall submit following documents for the HV Station proposed.

- General Arrangement drawing of the HV station (including switchyard), showing plans, foundation plans, termination details and elevations.
- Contractor shall submit type test certificates of various equipment issued by a Internationally accredited laboratory shall be accepted.
- Type and routine test various equipment certificated at the manufacturer's works
- The design calculations for earthing and structures.
- Following are the documents various equipment that shall be submitted along with the deliveries:

- The design calculations for earthing, short circuit and structures.
- Technical literature giving complete information of the components / equipment.
- Installation, Operation and Maintenance Manual complete with all relevant information, drawings and literature for auxiliary equipment and accessories, characteristics curves for relays etc.
- A comprehensive spare parts schedule.

Testing and Inspection

FAT shall be conducted in accordance with the relevant standards mentioned below.
The following type test and special test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar transformer by IEC or STL accredited laboratory.

Type Tests:

- Lightning impulse (Full & Chopped Wave) test on windings as per IS 2026-3/IEC 60076-3
- Temperature Rise test at a tap corresponding to maximum losses as per IS 2026-2/IEC 60076-2. Dissolved Gas Analysis (DGA) shall be conducted on oil sample taken before and

immediately after temperature rise test. Gas analysis shall be as per IS 9434/IEC 60567 and results will be interpreted as per IS 10593/IEC 60599.

Special Tests:

- Short circuit withstand test as per IS 2026-5/IEC 60076-5
- Measurement of zero-sequence impedance as per IS 2026-1/IEC 60076-1
- Measurement of harmonics of no-load current as per IS IEC 60076-1
- Measurement of acoustic noise level as per NEMA TR-1

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by IEC or STL accredited laboratory or witnessed by Employer.

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

- Measurement of winding resistance at each tap
- Measurement of voltage ratio between HV and LV windings at each tap Check of vector group
- Measurement of no-load loss and no-load current at 90%, 100% & 110% of rated voltage
- Measurement of short-circuit impedance and load loss at principal and extreme taps
- Magnetic balance test & magnetizing current test as per CBIP manual publication no. 295
- Separate source voltage withstand test
- Induced over voltage withstand test
- Measurement of insulation resistance and polarization index
- Measurement of tan delta and capacitance of winding
- Core isolation test
- Marshalling box functional test
- IR Measurement on wiring of marshalling box
- Test on off-load tap changer
- Breakdown voltage test on transformer oil as per IS 335
- Jacking test followed by D.P. test
  Oil leakage test on completely assembled transformer along with radiators
- Ratio test and connection group test
- Insulation oil test
- Tank sealing test

3.5.4 **Transformer and switchyard earthing**

1) The transformer neutral shall be directly buried. The transformer tank, cable box, marshalling box and all other body earth points shall be earthed.
2) The transformer shield shall be earthed separately using a minimum of two earth electrodes. Earthing conductor between the shield bushing and earth electrodes shall be copper flat of suitable size not less than 25 mm x 6 mm.
3) The neutral and body of the auxiliary transformer shall be earthed.

4) The metallic frames of all switchyard equipment and support structures shall be connected to the earth grid by means of two separate and distinct connections.
5) On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded.
6) The earth plate shall be provided to facilitate its identification and for carrying out periodical inspection.

3.5.5 **Containerized LV Switchgear**

All equipment provided under distribution switchgear shall comply with latest revisions and amendments of the relevant IEC standards. In particular, the switchgear shall comply with the following standards and codes.

- IEC 61439-1: Low-voltage switchgear and control gear assemblies - Part 1: General rules
- IEC 61439-2: Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies
- IEC 60947-1: Low-voltage switchgear and control gear - Part 1: General rules
- IEC 60947-2: Low-Voltage Switchgear and Control gear: Circuit Breakers
- IEC 60947-3: Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
- IEC 60947-4-1: Low-voltage switchgear and control gear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
- IEC 60947-5-1: Low-voltage switchgear and control gear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
- IEC 62052-11: Electricity metering equipment - General requirements, tests and test conditions - Part 11: Metering equipment
- IEC 61869: Instrument Transformers
- IEC 60364 or IS 3043: Code of practice for Earthing
- IEC 60255: Measuring relays and protection equipment - Part 1: Common requirements
- IEC 61643-11 Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test
- IEC 60227-1 Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V IEC 60502-1 Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV))
- EN 50575 Power, control and communication cables - cables for general applications in construction works subject to reaction to fire requirements
- EN 60332-1-2 Tests on electric and optical fibre cables under fire conditions - Part 1-2

3.5.6 **Containerized HT (11 kV) Switchgear**

All equipment provided under HT switchgear shall comply with the latest editions and amendments of the relevant IEC standards. In particular, the switchgear shall comply with the following standards and codes.

- IEC 62271-1: High Voltage Switchgear and Control gear - Part 1: Common Specifications
- IEC 62271-100: High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
- IEC 62271-102: High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches

- IEC 62271-200: High Voltage Switchgear and Control gear - Part 200: AC Metal Enclosed Switchgear and Control gear for Rated Voltages above 1kV and up to and Including 52 kV
- IEC 61869: Instrument Transformers
- IS 3231: Electrical relays for power systems protection
- IEC 60255: Measuring relays and protection equipment
- IEC 61850 Communication networks and systems for power utility automation
- IEC 61131-3: Programmable controllers - Part 3: Programming languages
- IEC 60099-4 Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
- IEC 62271-200 High-voltage switchgear and control gear - Part 200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
- IEC 62271-1 High-voltage switchgear and control gear - Part 1: Common specifications
- IEC 62271-100 High-voltage switchgear and control gear - Part 100: Alternating current circuit breakers
- IEC 62271-102 High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switch
- IEC 62271-103 High-voltage switchgear and control gear - Part 103: Switches for rated voltages above 1 kV and less than 52 kV

1) Circuit breakers shall be of vacuum type. It shall comprise of three separate identical single pole units operated through the common shaft and shall be fully interchangeable both electrically and mechanically.
2) The circuit breaker operating mechanism shall be based on motor operated spring charging and it shall be re-strike free, trip free both electrically and mechanically, with anti-pumping feature.
3) The rated control voltage of the spring charging motor shall be 110 VDC/230 VAC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage. The spring charging motor shall have adequate thermal rating such that continuous sequence of the closing and opening operations is possible as long as power supply is available to the motor. It shall also be possible to charge the spring manually and close the breaker in the event of failure of motor / control supply to motor. Operating handle shall be provided for charging the operating mechanism. After failure of control supply to the motor, one open-close-open operation shall be possible with the energy contained in the operating mechanism.
4) The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring. The closing action of the circuit breaker shall compress the opening spring ready for tripping.
5) When closing springs are discharged after closing the breaker, they shall be automatically charged for the next operation.
6) Mechanical indicators shall be provided to indicate the OPEN/CLOSED positions of the circuit breaker and CHARGED/ DISCHARGED positions of the closing spring. An operation counter shall also be provided. These indicators and counter shall be visible from the panel front door without opening it.

Containerized switchgear with LV Panel

- They container shall be positioned in a way that they don't cause shadowing on PV modules at any time.
- These containers must have ISO 9001 certificate. They must comply with ISO guidelines such as ISO 830 (definitions & terminologies), ISO 6346 (classification codes & markings), ISO 1161 (corner castings), ISO 668 (dimensions & ratings), ISO 1496 (specifications & testing procedures).
- They must have main doors lined with suitable special gaskets and hydraulic door closers to ensure that thermal insulation and protection from dust ingress.
- Containers must have vinyl false and anti-static flooring (IEC 61340), electrical fitments, ventilation, windows, doors etc. They must be fitted with a head LED light at the door.
- They must have a fire detection system. They must have wide fire rated door openings and come fitted with multi forklift pockets.
- General specifications of container: (These are the minimum requirements; the contractor may provide better equipment than the one stated below without any additional cost to the employer)

#	Description	Specification
1	Construction Type	Prefabricated TEU based shipping / customized container cabin/s
2	Material used	Galvanized steel, Aluminium, Stainless Steel
3	Walls	Steel sheets or thick sandwich panel
4	Roof	Purlin beam + Metal sheets + Insulation (thick sandwich panel) + PVC false roof
5	Floor	Purlin Beam + Metal sheet + Insulation + Cement fibre board + false floor (vinyl, tiles etc.). The containers must be provided with anti-static flooring in all areas where electrical instruments will be housed.
6	Ventilation	The control rooms must have windows, exhausts or other forms of ventilation
7	Fire Detection & Protection System	Yes. The container must be equipped with fire alarms and other auto detection mechanisms
8	Others	Electrical systems, bolts & screws, external hook-ups must be as per requirements in accordance with international standards
9	Wind resistance	Resistant to wind speeds prevalent in the areas.
10	Door & Windows	Wide opening fire rated doors for easy ingress and fire rated windows for ventilation

Other Specifications for the containerized room shall be as follows:

#	Description	Specification
1	Humidity Range	5%-95% RH
2	Operating Temperature	-20^{o}C to +30^{o}C
3	IP Rating	55 (min)
4	Anti-Wind	Wind Speed ≤ 40m/s
5	Service Life	25 years
6	Input voltage range	380/400/415V +/- 15% (for 415, positive tolerance is 10%
7	Cable Routing	Cables shall be routed from the bottom or end
8	Temperature control range	18 – 32^{o}C

- For maximum cooling efficiency, the container must have thermal insulation on walls, ceiling and floor.

- The enclosure of each container shall be rated to IP 55, free-standing with lockable hinged doors. The equipment within the container shall be enclosed in NEMA 1 or better painted steel enclosures.
- The containers shall be installed under a canopy.
- A fire & smoke detection system shall be installed in the container of the system. In case of fire, a visual and audible alarm must be activated. The fire protection system shall be equipped with a UPS system to ensure functionality even in case of grid failures. When the smoke detection sensor detects an abnormality, it shall send a signal to alarm.
- Contractors should provide technical details on its fire detection, fire protection systems in the container.
- The container shall be secured to the concrete foundation using expansion bolts, thus preventing the container from horizontal vibration.
- The container shall be sealed on the foundation by cable inlet and fire-stop putty to ensure water resistance.
- The container should ensure anti-corrosion and fully welded to ensure waterproof.
- The container door should be waterproof and dustproof, and the transformer door should be configured with locks, all devices shall be able to be removed without removing the door.
- Lighting System - with internal light system shall include a general lighting system designed with ceiling LED lamps (IP20).
- All containers must be properly cladded by Aluminium Composite Panel and a NEA logo shall be inserted.
- Contractors should provide technical details on its fire detection.
- Container shall be separated from each other and from other equipment in accordance with applicable fire protection standards.

Mimic

- Mimic diagram shall be provided on panels. Mimic diagram shall be screwed on to the panels / desks and shall be made of anodized aluminium or plastic of approved fast colour. The mimic shall be 10 mm wide for horizontal run and 5 mm wide for vertical run.
- Semaphore indicators used for isolator positions, they shall be so mounted in the mimic that isolator (or breaker) closed position shall complete the continuity of the mimic. The mimic diagram shall incorporate red and green lamps for isolator position indication and controlling switches with indicating lamps for breakers.
- The lamps will remain steady where the hand operated semaphore positions correspond with the breaker position. The lamps shall flicker with a time delayed alarm if the semaphore position does not correspond with the breaker position.

Relays

- All relays shall be switchboard pattern, back connected draw-out type suitable for flush mounting and fitted with dust tight covers. The relays shall confirm to IEC. The relays shall be of Microprocessor based numerical and communicable. A set of test block and test lead for necessary secondary injection tests shall be included.
- All relays in draw out cases shall have suitable spring-loaded contacts for inserting test block. Relays shall be provided with hand/auto reset type contacts and flag indicators. The flag indication shall be suitable for external hand resetting and me-

chanically interlocked to prevent falling when relays are subjected to vibration.

- The rating of the auxiliary contacts shall not be less than 5 amps at 230 V AC and 1.5 amps for 110 V DC. All the circuit breakers controls shall be supplied with trip circuit supervision relays.

3.6 Power Plant Control and Monitoring system - PCMS

The PCMS shall provide interactive control and monitoring for specific parts of the PV power plants, the Battery Energy Storage Systems (BESS) and auxiliaries, as defined in this specification. Furthermore, all alarms and indications shall be available on Operator workstations.

3.6.1 General Requirements

- The system shall be a state-of-the-art, field-proven system based on microprocessor technology. The architecture shall foresee distributed intelligence comparable to an automated real-time control system for data acquisition, processing, transmission, storage and archival, graphical presentation and display.

- All components shall be of approved and reliable design with the highest attainable attributes for uniformity, interoperability and interchangeability. The design shall be modular to facilitate easy maintenance, fault diagnosis and repair of the components, and to support installation and expansion in increments.

3.6.2 Main Functionality

The PV-BESS hybrid systems will work under an AC-coupled (AC bus) configuration. The system is capable to operate as a standalone (off-grid) hybrid system and shall have provision to interconnect to the main grid at 11 kV through a bus coupler. The distribution feeder for loads operates at 11 kV. The PCMS will be able to control all these sources from one central control point.

3.6.2.1 *Provision for Protection of hydropower plants from back feeding*

To provision for future synchronization of the solar + BESS plant with existing and upcoming mini hydro projects at all 4 sites the PCMS must be capable of ensuring grid stability and restricting back feed to the hydropower generator by curtailing the output power of the PV inverters when needed. The controller will have to constantly monitor the load demand, hydropower generator available capacity and PV generation capacity and manage the system accordingly.

3.6.2.2 *Power management and grid formation*

Hydropower generators form the primary grid and provides all ancillary system functions. The power conditioning system of BESS (battery inverter) should also be able to form the grid and synchronise with the hydropower generator. The PV plant will be seen as a negative load by the hydropower generators and it will inject its produced energy into the grid. The battery will be used to supply power in the morning and evening hours when hydropower is not adequate and during the day time it will be used to stabilize the grid when required (f/U) against sudden power fluctuation (from the load and/or the PV plant).

PCMS will constantly monitor the load demand and available source of power in all sources at the same time and operate the grid without causing any blackout.

3.6.2.3 *Maximum utilization of PV power and system stability*

During the day, the PV and hydropower generator provides 100% of the load and charges the battery. In this scenario, most of the energy in the system will be provided by the PV system. The hy-

dropower generator will still act as a frequency and voltage regulator but shall be supported by the BESS and the PV system with reactive and active power to serve the demanded energy. BESS shall be able to support the system by taking over the load in case of sudden PV drops and load variations. The PCMS must always react quickly enough to avoid a blackout in the system due to sudden PV drops or load increases.

3.6.2.4 *Battery Protection*

If the battery is fully charged and the PV output power is higher than the loads in the system, the PV power can be curtailed by frequency droop to protect the hydropower plant. When the system is interconnected to the grid, the excess power will be fed to the grid and there will be no curtailment of inverter power.

The battery is discharged during the morning and evening hours when hydropower is not adequate. The battery will discharge until the defined minimum State of Charge (SOC) is reached. When the system is not connected to the grid (off-grid) and the state of charge of the battery has reached its minimum level (SOC min) and output from PV and hydro is not adequate to supply power to the loads, there will be partial load curtailment to protect the battery.

When the system is connected to the grid (on-grid) and the state of charge of the battery has reached its minimum level (SOC min) and output from PV and hydro is not adequate to supply power to the loads, the grid will charge the battery and supply power to the loads.

3.6.2.5 *Emergency Mode*

It is mandatory that an emergency mode for the PV inverters is implemented. This mode will automatically be activated in the PV inverters, once the communication to the PCMS is lost due to component failure, communication cable break or any other reason.

Once the communication is lost, the PV inverter shall automatically change into emergency mode. The PV inverter shall then work as a normal grid-connected inverter that is limited in its output power to a certain value that is to be set during commissioning and shall be easily adjustable by the operator at a later stage if necessary, keeping in mind that there is no back feed to the hydropower generator.

All other parameters on the inverter shall also be easily changeable for this specific mode and may be different to the normal operation.

3.6.3 PCMS protection and security

The PCMS or each subsystem shall be designed in accordance with ISO/IEC 27002, ISA 99 or equivalent Standards.

For security reasons, all log-in and log-out events shall be logged in the event list. All user changes and modifications to the system as well as parameter and program modifications shall be lodged with the exact time and operator's assignment in the event list too.

Those parts of the system that are electrically connected to cables leaving a building shall be fitted with over-voltage protection.

The PCMS equipment shall be connected via a common potential equalization bar to the earthing network Station.

3.6.4 PCMS Cabinets

Central Unit Servers and associated accessories shall be accommodated in dedicated equipment cabinets.

For indoor application, the cabinets shall be constructed as follows:

- Standard sized steel cabinets with external painting colour as per Employer/Engineers approval
- Certified for minimum IP41 protection class
- Power distribution box with main filter and main switch (separate 2-pole breakers for each device)
- Front-patches for LAN cabling
- Cable organisers, cable trays, suspensions and termination components with strain relief for all internal and external cabling
- Over-voltage protection for all devices (if required)
- 20 % housing space for future equipment
- Ventilation fan to ensure that maximum allowable operating temperature of all equipment inside the cabinets shall not be exceeded
- Bottom cable access
- Document pocket
- Grounding bus bar for earthing connection
- Doors with glass front and locking system
- Inner light and power socket for maintenance
- Provision of easy access for maintenance and repair, all devices with rear plugs shall be draw-able

3.6.5 Electrical Interface Units

EIUs as data acquisition modules shall be designed and provided to perform the interface between the electrical equipment and the PCMS. The EIU hardware shall be fitted with process interface slot-in modules for digital inputs and outputs, analogue inputs, Ethernet communication modules, etc. Output from all generating sources shall be measured directly and not through any intermediary meters such as Battery Control Units or Generator controllers.

The EIU shall be of same make and type all over the Plant and shall have Ethernet connection with PCMS. The power supply of the EIU shall be powered from the UPS.

3.6.6 Performance and Reliability

All equipment shall be of high quality and reliability. The overall system availability of the PCMS shall be 99% or better.

All equipment shall be protected against cyber-attacks. PCMS lifetime shall be 25 years.

3.6.7 Software Requirements

The PMCS shall be based on standard proven firmware and software, which shall already been implemented in other systems. The software engineering tool shall be provided to configure, set up and modify the data acquisition, data processing and database system components. The software application shall include facilities to perform programmable logic functions.

The system shall have monitoring and self-diagnostics features for both, hardware and software.
A licensed software copy required for the proposed system shall be provided. The latest proven anti-virus software shall be installed in the PCMS.

All logins to the system shall be password protected. Data transmission via the public internet shall be encrypted.

3.6.8 Alarm and Event Management

All alarms including system alarms and important events shall be listed up on the display. The lists shall be in chronological sequence showing:

- The precise date and time with the specified resolution in actual sequential of events;
- Plant identification code;
- Clear text/denomination of alarms and events;
- Status message (open, close, off, high, low);
- The actual value in case of high/low alarms derived from analogue values;
- Sorting of alarms per subgroup shall be possible.

3.6.9 Report Generation

Automatic and configurable generation of typical reports (total or detailed power generation data, problems, efficiency analysis, weather reporting etc.) shall be supported internally or with the help of formatted data output and provisioning of corresponding templates and input filters for e.g. MS Excel or similar. It shall be possible to print the generated reports. The format of the logs and reports shall be subject to the approval of the Employer.

3.6.10 Data Communication Network

The PCMS shall have communication via Modbus TCP to all energy producers, respectively hydropower generators, PV inverters and BESS units. It will receive all necessary measurement data from those sources, such as voltage, ampere, cos phi, battery SOC, frequency and warnings/alarms at the connection points of the sources. According to the actual state of the system, it will then decide and send the control to the relevant sources, if and how they should react, be switched on or off or regulate their power output. The communication shall be realized with network cables CAT 6 and fibre optic cables for longer distances.

The PCMS shall also be able to include any other sensors necessary for the functioning of the system and provide the data of additionally included sensors in the Modbus protocol. The communication protocol of the sensors to be included may be of a different kind than Modbus.

The supplied system shall include a data communication network to ensure the proper interconnection of all components of the PCMS such as but not limited to: cables, accessories, media converters, repeaters, amplifiers, switching and routing equipment including accessories, their housing as required, as well as the management systems necessary to operate the data communication network.

3.6.11 Power Supply & Cabling

The power supply for PCMS shall be provided by UPS. All redundant devices shall have redundant power supply modules.

The Contractor shall perform all cabling and installation works for outdoor and indoor equipment as well as the interface interconnection and termination at existing devices. No cable joints shall be used for interfacing PCMS with any other equipment.

3.6.12 Fibre Optic Cables (FOC)

Depending on the requirements of the proposed control system single mode and/or multi-mode FOCs shall be used. The manufacturing, construction, labelling and testing of the fibre optic cable system shall meet the requirements established in the relevant applicable ITU and IEC codes, standards and recommendations.

3.7 Utility compatibility

3.7.1.1 *General*

The applicable standard related to interconnecting an inverter to a utility network is IEC 61727: 2004, "Photovoltaic (PV) systems – Characteristics of the utility interface". The inverter's AC voltage, current and frequency shall be compatible with the utility system in accordance with IEC 61727.

3.7.2 Normal voltage operating range

Inverter shall operate at and shall support the network voltage. The inverter shall synchronise with the utility network before a connection is established. The inverter shall not generate the voltage of the grid but shall inject current into the system.

3.7.3 Flicker

The operation of the inverter, in conjunction with other existing and future loads at the same point of connection, shall not cause flicker levels to increase beyond the levels specified in IEC 61000-3.

3.7.4 DC injection

The static power converter of the inverter shall not inject DC current exceeding 1 % of the rated AC output current into the utility AC. Interface under any operating condition in accordance with EN 50178. This relates specifically to inverters where the static power converter has no simple separation from the utility network.

3.7.5 Electromagnetic Compatibility

EMC for possible electromagnetic emissions from facilities or equipment to be installed, so the installation team is right to safe conditions of use, as well as the equipment to be connected to it. The inverter must be prepared and be electromagnetic compatible in function of electromagnetic immunity (IEC61000-6-2) and Emission (IEC61000-6-4).

The BESS equipment shall not create Electro-Magnetic interference (EMI) with other equipment. The Contractor should indicate any Electro-Magnetic interference radiation generated by the BESS or other equipment, the system will be located within 1 km of an airport, and Electro Magnetic interference studies may be required at no additional cost to the employer if required.

3.7.6 Harmonics and waveform distortion

In accordance with IEC 61000-3, only devices that inject low levels of current and voltage harmonics will be accepted; the higher harmonic levels increase the potential for adverse effects on connected equipment.

Acceptable levels of harmonics, voltage and current depend upon distribution system characteristics, type of service, connected loads or apparatus, and established utility practice. The embedded generator output shall have low current-distortion levels to ensure that no adverse effects are caused to other equipment connected to the utility system.

Total harmonic current distortion shall be less than 5% at rated generator output in accordance with IEC 61000-3-. Each individual harmonic shall be limited to the percentages listed below.

3.7.7 Power factor

The inverter shall not inject reactive power into the utility network, while the drain of reactive power shall be limited to a power factor of 85%. The inverter shall operate at these power factors in the range 10% to 100% of nominal power.

3.7.8 Synchronization

The inverter shall synchronize with the utility network before the parallel connection is made. Automatic synchronization equipment shall be the only method of synchronization. The limits for the synchronizing parameters for each phase are:

- frequency difference: 0.3 Hz,
- Voltage difference: 5 % = 11.5 V per phase, and phase angle difference: 20°.

3.7.9 Safety and protection

General: The safe operation of the inverter in conjunction with the utility network shall be ensured at all times.

Safety disconnection from utility network: The inverter shall automatically and safely disconnect from the grid in the event of an abnormal condition. Abnormal conditions include

- network voltage or frequency out-of-bounds conditions,
- loss-of-grid conditions and prevention of islanding
- DC current injection threshold exceeded
- PV field earth leakage
- Inverter over temperature

Disconnection switching unit: The inverter shall be equipped with a disconnection switching unit which separates the inverter from the grid due to the above abnormal conditions.

- The disconnection switching unit shall be able to operate under all operating conditions of the utility network.
- A failure within the disconnection switching unit shall lead to disconnection and indication of the failure condition.
- A single failure within the disconnection switching unit shall not lead to failure to disconnect.
- Failures with one common cause shall be taken into account and addressed through adequate redundancy.
- The disconnection switching unit shall disconnect from the network by means of two series switches. Each switch shall be separately rated to the inverter's nominal power output. At least one of the switches shall be an electromechanical switch while the second switch may be part of the existing solid state switching circuits of a utility-interconnected static power converter. The electromechanical switch shall disconnect the inverter on the neutral and the live wire(s).
- The fault current breaking capacity of the disconnecting switch shall be appropriately sized for the application.

Abnormal conditions can arise on the utility system and requires a response from the connected inverter. This response is to ensure the safety of utility maintenance personnel and the general public, and also to avoid damage to connected equipment. The abnormal utility conditions of con-

cern are voltage and frequency excursions above or below the values stated in this clause. The inverter shall disconnect if these conditions occur. The parameters for disconnection shall correspond to those below, but shall be adjustable.

Over-voltage and under-voltage: The inverter shall cease to energize the utility distribution system should the network voltage deviate outside the conditions specified in table below. This applies to any phase of a multiphase system. The system shall sense abnormal voltage and respond. The following conditions shall be met, with voltages in r.m.s. and measured at the POC (Point of Connection). All discussions regarding system voltage refer to the nominal voltage. The parameters for disconnection shall correspond to those below, but shall be adjustable in the field.

Over-frequency and under-frequency: The inverter system shall cease to energize the utility network when the utility frequency deviates outside the specified conditions. When the utility frequency is outside the range of 48.75 Hz and 51.25 Hz, the system shall cease to energize the utility.

Prevention of islanding: An islanding condition shall cause the inverter to cease to energize the utility network within 2 s, irrespective of connected loads or inverters. One active islanding detection method and one passive island detection method shall be used to avoid an unintentional island.

Active and passive types of anti-islanding protection of inverters	
Active type	**Passive type**
Frequency shift	Power phase jump detection/ voltage vector shift
Active power fluctuation	3^{rd} harmonic voltage rise
Reactive power fluctuation	Frequency change rate detection/ Rate of Change of Frequency (ROCOF) @2.5Hz/sec
Load fluctuation	

DC current injection: The static power converter of the inverter shall not inject DC current greater than 1 % of the rated AC output current into the utility interface under any operating condition. The inverter shall cease to energize the utility network within 500 ms if this threshold is exceeded.
Response to utility recovery: After a voltage or frequency out-of-range condition that has caused the inverter to cease energizing the utility network, the inverter shall not re-energize the utility network for 60 s after the utility service voltage and frequency have recovered to within the specified ranges.

Meters- There shall be redundant bidirectional energy meters for production and consumption loads. The 6operational meters will be located at the delivery station in the PV plant.

3.8 Earthing

3.8.1 General requirements

The bonding of equipment should prevent dangerous voltage differentials arising between metallic equipment during fault conditions, and provide alternative conduction paths to power cables should ground surges from nearby lightning strikes arise.

The main earth point for the system shall be a systems earth electrode, as specified. It shall be located directly below each array structure.

The earth electrode shall be the common point for the casings of all balance of system components, and the array structure.

The risk of lightning strikes varies according to location. However, for all site locations the following basic guidelines will apply, as the electrical distribution is contained within one building.

For some sites additional lightning protection circuits may be required, but for the system configurations all within one building that no additional protection will be required.

3.8.2 Earth electrode

Two types of earth electrode are suitable:

- Spike earths
- Multiple spike earths (trench earth)

Bare copper, in stranded, strip or rod form are satisfactory earth materials in non-aggressive soils. Because galvanised ferrous materials corrode sacrificially to copper, galvanised iron and steel electrodes should not be buried in close proximity to bare copper. The down conductors shall be connected to copper earth spikes of minimum length 1200mm.

The spikes shall be driven vertically into the ground till buried to a depth of at least 0.3 m. If necessary, several spikes shall be interconnected as a trench earth to achieve the required resistance.

10mm2 shall be used as earth straps to bind components to the earth electrode. No loops shall be created to avoid inductive voltage. PE cable will be wired jointly with the positive and negative unipolar cable. Under no circumstances shall connection points, bolts, screws, etc. used for bonding or earthing be utilised for any other purpose. It will be responsibility of the contractor to supply and fit earth terminals or clamps on equipment that must be earthed where these are not provided.
Considering the site condition contractor is to design and install suitable earthing system using appropriate equipment if required apart from the ones mentioned above at no additional cost to the employer.

3.8.3 PV mounting structure earthing

PV mounting structure and PV module frame shall be connected to the earthing system.
Earthing of exposed conductive parts of electrical equipment, including structural metalwork, is also generally required. It is recommended that a trench be used to bond the individual earth

spikes together underground. Continuity between the module frames and the mounting structure shall be maintained.

3.8.4 Equipment Earthing and Bonding

All metal equipment and casings shall be bonded together, as they are inter-connected by the power cables. The bonding shall be made using copper conductors of 10mm^2 minimum. A separate conductor shall be used specifically for that purpose. The resistance requirement in between enclosures shall be less than 1 ohm. The resistance measured against ground shall be less than 1 ohm.

The specific standards applicable for earthing requirements are:
IEC 60364-7-712 Electrical installations of buildings Part 7-712 Requirements for special installation locations-Solar photovoltaic (PV) power supply systems
IEC 60364-5-54 Electrical installations of buildings Part 5-54 Selection and erection of electrical equipment - Earthing arrangements, protective conductors and protective bonding conductors.
Earthing system shall comply with the latest edition of IEEE80.

To be submitted:

- Site plan indicating earth pits, earthing strip routing, road cross overs etc.
- Earthing calculations along with schematic drawing for the entire network
- Drawing showing the dimensions, materials and position of all components, earth electrodes, earth conductors etc.

3.9 Overvoltage protection

Lightning protection shall be designed inherently into the system configurations, earthing, and some level of surge protection shall be built into the inverters themselves.

For mitigation of overcurrent the contractor shall follow the installation practice below:

- All DC cables should be installed to provide as short runs as possible and positive and negative cables of the same string or main DC supply should be bundled together, avoiding the creation of loops in the system. This requirement for short runs and bundling includes any associated earth/bonding conductors.
- Long cables (eg. PV main DC cables over about 50 m) should be installed in earthed metal conduit or trunking, or be screened cables such as mineral insulated or armoured.

Additionally, the following overvoltage protection devices shall be provided:

- DC system: surge arrestors, class 2, on the inverter DC inputs or DC distribution box shall be provided.
- AC system: surge arrestors, class 2, at the incoming point of supply shall be provided. The surge arrestors shall be installed in the Main DB.

The surge arrestors shall be of class 2 with visual fault indication, 40kA (8/20) according to IEC 61643-1 for sensitive electronics, clamping voltage to less than 1,500V. Units with replaceable LP modules are required.

3.10 Civil and Mechanical Requirements

3.10.1 General Requirement

The intent of specification covers the following:

Design, engineering, drawing and construction of all civil works at solar plant and associated facilities. All civil works shall also satisfy the general technical requirements specified in other Sections of Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per relevant British standard codes (B S Codes)/ equivalent International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant International Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of NEA/Consultant.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA/Consultant. For all structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the plant and associated facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements assessing the actual site condition including road access to the site.

3.10.2 Topographical Survey

(i) The contractor shall be responsible for detailed Topographical Survey of the proposed project site. The work shall be carried out through an agency with relevant experience and qualified survey team.

(ii) The Topographical survey shall be conducted at 1m x 1m grid, or as directed by the Engineer, only with the help of digital surveying instruments like Total Station.

(iii) Micro level contouring is required for the specific site for the purpose of structure / foundation levelling and drainage planning and rainwater diversion.

(iv) The Contractor shall carry the Benchmark from nearest GTS Benchmark, or any other established permanent structure as approved by the Engineer, by fly-levelling and establish one permanent benchmarks (PBM) at site. All subsequent transfer of levels shall be carried out with respect to this PBM. The work shall also include constructing permanent reference pillars (RP) at suitable locations as directed by the Engineer.

(v) The survey work shall be carried out in UTM grid system. The contractor shall also establish the latitudes and longitudes and UTM coordinates of all the corners of the project site. At least 25m width of the adjoining plots and surrounding areas shall also be covered in the survey for correlation with adjoining plots and facilities. The grids for the survey work shall be established in N-S & E-W direction (corresponding to Geographical North or Plant North) as directed by the Engineer.

(vi) The record of measurement of all Reduced Levels (RL) shall be submitted in digital format, (in x, y z coordinate system) along with preliminary contour plan of the site, for Engineer's review before submission of final contour map. The contour interval shall be 0.5m or as required for proper representation of the topography. The Contractor shall submit survey maps of the site in 1:5000 scale or as suitable, indicating grid lines and contour lines.

(vii) Present use of the site, existing drainage pattern of the site, possibility of water logging shall also be captured in the document. The project plot boundary with coordinates of all corner points shall be marked on the contour map.

3.10.3 **Geotechnical Investigations**

The Contractor shall perform geotechnical investigation including a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the site so that the foundation of the various structures can be designed and constructed safely and rationally. The report shall contain all soil parameters for type of foundation i.e., pile or open type, soil treatment if any etc. to be used for the design of civil foundations.

The Contractor shall visit the site to ascertain the soil parameters. Any variation in soil data shall not constitute a valid reason for any additional cost & shall not affect the terms & conditions of the contract. Subsurface investigation must be conducted for all the critical locations i.e., transformers, module mounting structures, BESS containers etc. as per IS 1892.

Number and location of BHs, ERTs and TPs shall be decided as per the project layout, site topography and soil conditions in consultation with the Employer. The proposed locations shall fairly represent the total project site to get the complete required geotechnical information. There shall be minimum 3 no. of BH per site (targeting sites for major structures such module mounting structure, transformer & BESS containers), 1 (one) Trial pit, 3 nos. of Ground water samples for laboratory investigations. The soil/ rock samples for laboratory investigations shall be collected from each borehole and trial pit in sufficient number. The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-change.

The contractor shall be responsible for detailed Geotechnical investigations at the proposed project site for the purpose of foundation design for various structures such as module mounting structures, transformers, BESS containers, containers for control room cabins, guard house etc. and other design/ planning requirements. The investigation work could be carried out through any accredited lab. The contractor shall submit the credentials of the proposed agency along with relevant certificates in support thereof for verification/ approval of the Investigation Agency by the Engineer.

Electrical Resistivity Test - this test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipment and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to relevant British standard codes (B S Codes)/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant British standard codes (B S Codes)/ equivalent International Standards. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 1 m upto a distance of 50.0 m.

Slope stability, erosion susceptibility, landslide susceptibility etc. need to be assessed at each site. Plate load tests shall be conducted each at location of transformer area, BESS container area and any other site as required, to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to relevant IS/ BS/ equivalent International Standards. Plate load test shall be performed at the proposed foundation depth below finished ground level for bearing capacity.

All provisions regarding excavation and visual examination of pit shall apply here. Unless otherwise specified the reaction method of loading shall be adopted. The load shall be increased in stages. Under each loading stage, record of Time vs. Settlement shall be kept as specified in relevant IS/ BS/ equivalent International Standards.

Backfilling of the pit shall be carried out as per the directions of the employer. Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

3.10.4 **Other Investigations**

(i) The contractor shall also obtain and study other input data at proposed project site for design of the project from metrological department/ local govt. authorities. This shall include data related to Rainfall, Maximum & Minimum ambient Temperature, Humidity etc.

(ii) The contractor shall carry out Shadow Analysis at proposed site and accordingly design strings and array layout with optimum use of space, material, and manpower. In case of large variations in topography (30^{o} to the horizontal) the study shall also include the effect of topographical variations on array layout and MMS structure design adequacy and stability. The contractor shall submit all the details/ design to the Engineer for review/ approval.

(iii) The contractor shall also identify potential quarry areas for coarse and fine aggregates to be used for concrete and shall use nominal mix design for concrete grades to be used in construction of all concrete works before start of construction.

3.10.5 **Excavation and Earthworks**

(i) The contractor shall excavate earth, rock, stumps and all the other materials encountered as required for construction of the foundations, underground containments and trenches. The Contractor shall place all suitable excavated materials in backfill or in graded embankment in the immediate area at structures. Materials found to be unsuitable for foundation backfill or grading shall be wasted and disposed of at Contractor own expense and shall be backfilled with select borrowing material.

(ii) Excavation shall be maintained in a clean, safe and sound condition until completion of the foundation construction and shall be done to prevent flooding by surface runoff. Suitable pumping equipment shall be provided and used to dewater excavation so that all installation work and backfilling is performed in the dry state. Any previously prepared foundation bearing surface that is softened by water runoff or otherwise contaminated before placement of the structure foundation shall be excavated and replaced at the Contractor's expenses.

(iii) In those excavation where the base is unstable, lies below groundwater level, or has been over excavated, the Contractor shall provide and place a layer of crushed stone, or selected backfill, or borrow to stabilize the base for placement of foundation.

(iv) Backfill shall be placed in not greater than 20cm lifts before compaction. Each lift shall be thoroughly compacted before the following lift is placed, Pneumatic or equivalent tempers shall be used on cohesive materials: vibratory compactors shall be used on non-cohesive materials. Compaction shall achieve a density at least 95% of the maximum dry density of the surrounding undisturbed earth. Large stones or rock fragments may be used in the backfill provided they do not interfere with proper compaction. Particles larger than 25 cm shall be placed not nearer than 0.5 m of the structure and at least 1.0m below ground surface.

(v) Rock particles larger than 10 cm shall not be in contact with the concrete.

(vi) Payment for the contract item Excavation and backfill, will be made as per the price bid. This shall include excavation in all kinds of soil including rock/concrete/road, all leads and lifts including back filling, shoring, compacting, dewatering (if required) and disposal of surplus earth/ rock to a suitable location decided by the employer. The quantity of excavation for all foundations/pits shall only be measured. The measurement of excavation for all concrete works shall be made considering dimension of the pit keeping 150mm gap around the base pad (concrete) or approved drawing or excavated pit, whichever is less.

3.10.6 **Temporary Site Installations**

(i) 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 with own responsibility. For the avoidance of doubts the Employer shall not be responsible for the provision of land for such off-site areas. The temporary installations include labour camps, offices and car parking for Contractor and his sub-contractors, workshop facilities, lay-down areas, etc.

(ii) Site installations and camps shall respect the demands of health and safety and environmental protection. The contractor shall ensure proper storage of machinery and avoid oil spillage.

(iii) 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.

3.10.7 **Area Grading and Land Development**

The Finished Grade Level (FGL) of the proposed plant shall be fixed with reference to the highest flood level (HFL) and surrounding ground profile at proposed site to avoid flooding of plant site. The data regarding HFL at proposed site shall be obtained from the metrological department by the contractor. In case of absence of this data, the contractor shall assess the required information through local site reconnaissance. The minimum plinth level open installations shall be 450mm above FGL. Module mounting structure foundation/ Pile cap, or any other pedestal shall be min. 300mm above FGL. Top of transformer foundation pedestal shall be min, 600mm above the FGL.

A detailed drawing for site levelling and grading (if necessary) shall be submitted by the contractor before commencement of construction of all buildings, plinth for open installation and transformer works. The estimated volume of cutting and filling shall also be marked on the Grading drawings for reference.

Contractor shall consider the effect of the existing ground slope on the design of MMS structure.

The contractor is responsible for making the site ready and easily approachable by clearing bushes, felling of trees, cutting, filling with excavated earth or borrowed earth. The filling for levelling/ reclaiming the ground/ area shall be done in layers not more than 150mm of compacted thickness in case of cohesive (clayey) soils and 250mm compacted thickness in case of granular (sandy) soils with compaction up to 95% (of modified proctor density) and 80% (of relative density) respectively. The slope at edge of graded areas shall not be steeper than 1:1.5 (1 Vertical: 1.5 Horizontal) in cutting and 1:2 (1 Vertical: 2 Horizontal) in filling. In case of filling with rock material, the edges shall be provided in line with provisions of relevant IS standard and/or Nepal standards.

It shall be ensured that the land grading and levelling is done properly to ensure for free flow of surface run-off. It shall be ensured that the land is used optimally to have maximum solar power generation considering full utilization of the plot areas. It is advisable to follow the natural flow of water at the ground as far as possible for drainage design.

3.10.8 **Containerized office cum control room along with PCMS**

- Control rooms shall be positioned in a way that they don't cause shadowing on PV modules at any time. Control room must be set up in customized containers / portable modular cabins.
- These containers must have ISO 9001 certificate. They must comply with ISO guidelines such as ISO 830 (definitions & terminologies), ISO 6346 (classification codes & markings), ISO 1161 (corner castings), ISO 668 (dimensions & ratings), ISO 1496 (specifications & testing procedures).
- All cabins must have main doors lined with suitable special gaskets and hydraulic door closers to ensure that thermal insulation and protection from dust ingress.
- Containers must have vinyl false flooring, all required furniture, electrical fitments, ventilation, windows, doors etc. They must be fitted with a head LED light at the door.
- Control cabins must have a fire detection system. They must have wide door openings and come fitted with multi forklift pockets.

- Control rooms for modular plot: According to the system design and inverter selection, control rooms shall be planned. In case of indoor installation of inverter, a similar portable modular cabin or container maybe used.
- General specifications of container cabins: (These are the minimum requirements; the contractor may provide better equipment than the one stated below without any additional cost to the employer)

#	Description	Specification
1	Construction Type	Prefabricated TEU based shipping / customized container cabin/s
2	Material used	Galvanized steel, Aluminium, Stainless Steel
3	Walls	Steel sheets or thick sandwich panel
4	Roof	Purlin beam + Metal sheets + Insulation (thick sandwich panel) + PVC false roof
5	Floor	Purlin Beam + Metal sheet + Insulation + Cement fibre board + false floor (vinyl, tiles etc.). The containers must be provided with anti-static flooring (IEC 61340) in all areas where electrical instruments will be housed.
6	Ventilation	The control rooms must have windows, exhausts or other forms of ventilation
7	HVAC	Yes. The control room must be equipped with temperature regulating HVAC
8	Fire Detection & Protection System	Yes. The container must be equipped with fire alarms and other auto detection mechanisms
9	Others	Electrical systems, bolts & screws, external hook-ups must be as per requirements in accordance with international standards
10	Wind resistance	Resistant to wind speeds prevalent in the areas.
11	Door & Windows	Wide opening doors for easy ingress and windows for ventilation

Other Specifications for the containerized control room shall be as follows:

#	Description	Specification
1	Humidity Range	5%-95% RH
2	Operating Temperature	-20^{o}C to +30^{o}C
3	IP Rating	55 (min)
4	Anti-Wind	Wind Speed ≤ 40m/s
5	Service Life	25 years
6	Input voltage range	380/400/415V +/- 15% (for 415, positive tolerance is 10%
7	Cable Routing	Cables shall be routed from the bottom or end
8	Temperature control range	19 – 32^{o}C

- For maximum cooling efficiency, the container must have thermal insulation on walls, ceiling and floor.
- The enclosure of each container shall be rated to IP 55, free-standing with lockable hinged doors. The equipment within the container shall be enclosed in NEMA 1 or better painted steel enclosures.
- The containers shall be installed under a canopy.
- The container shall be secured to the concrete foundation using expansion bolts, thus preventing the container from horizontal vibration.
- The container shall be sealed on the foundation by cable inlet and fire-stop putty to ensure water resistance.

- The container should ensure anti-corrosion and fully welded to ensure waterproof.
- The container door should be waterproof and dustproof, all devices shall be able to be removed without removing the door.
- Lighting System - with internal light system shall include a general lighting system designed with ceiling LED lamps (IP20).
- All containers must be properly cladded by Aluminium Composite Panel and a NEA logo shall be inserted.
- Contractors should provide technical details on its fire detection, fire protection systems in the container.

3.10.9 **Roads**

Paved peripheral, internal and inter-row pathways must be constructed wherever required. Contractor will be responsible for ensuring that the roads leading up to the site are cleared for trucks to carry equipment up to the place of installation.

3.10.10 **Surface/ Area drainage**

(i) The contractor shall design and construct storm water drainage network for smooth disposal of storm water from the plant to the nearest available drainage outlet.

(ii) The storm water drainage system shall be designed and planned to ensure no water stagnation in the plant.

(iii) The coefficient of run-off for estimation of design discharge shall be considered as per catchment characteristics, however it shall not be less than 0.6.

(iv) The drainage scheme shall be designed considering the plant plot area and the surrounding catchment area contributing to the plant area drainage as per the topography.

(v) The storm water drainage system shall be a network of open surface drains (with rectangular or trapezoidal cross section) and shall generally be designed to follow the natural flow of water and ground contours.

(vi) Suitable size plant peripheral drain as per design (min. 500mm wide x 500mm deep) along inside of plant boundary wall/ fence shall be provided for smooth channelization of outside storm water and to avoid flooding in the plant. At Gamgadi if terraces/benches are created for panel installation, each terrace must have 1 drain to ensure no water is collected on the terraces.

(vii) The structural design of drains shall be as per provisions of relevant international/national standards and good industry practice.

(viii) The drain outfall shall be connected to the nearest existing natural drain(s)/ water body outside plant premises, and it shall be ensured that the drainage water shall not re-enter the plant nor encroach/ flood in the adjacent property/ plot.

(ix) The proposed drainage scheme along with design calculations and drawings shall be submitted to the Engineer for review/ approval before start of construction.

3.10.11 Wastewater Systems

The wastewater streams must be separated according to their origin and/or type of pollution and the type of treatment that they require. Thus, as a minimum requirement, the following separate treatment system must be provided:

Sanitary wastewater system: The wastewater from toilets, tea kitchens, showers and related rooms shall be properly collected in a storage tank with separation of solid proportions and liquid proportions. The solid waste and the wastewater shall be collected by a truck as required and disposed of according to all applicable codes and standards and local and national guidelines of environmental protection.

3.10.12 Plant Layout

(i) The contractor shall submit drawing showing proposed Project Plant and SPV module Layout.

(ii) The Plant and SPV module layout shall be a comprehensive drawing showing various requirements of the project like, Reference coordinate grid, Geographical and Plant North, Layout of boundary fence including coordinates of all corner points, Location of main entrance gate and any other access gates as per project needs, Proposed Array layout, Lightening arrester, Storm water drains, Corridor for buried cables etc.

(iii) The cable corridor shall be laid through clear gap between arrays and shall not be laid below modules for easy maintenance.

(iv) The drawing shall be in suitable scale to have proper representation of the information.

(v) The Plant & SPV module layout drawing shall be submitted by the contractor for review/approval by the Engineer.

3.10.13 Design Loads

Unless otherwise specified elsewhere, Dead load, Live load, Wind load and Seismic load for all structures shall be considered as per provisions of relevant international standards.

The following minimum imposed load as indicated for some of the important areas shall, however, be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered.

Area	**Imposed Live Load**
Roof	According to Nepal Building Code
Outdoor platforms	5.00 kN/ Sqm
Underground structures such as Sump, Pit, Trench, Drain, UG tank etc.	In addition to Earth pressure and Ground water table at FGL, a surcharge of 20kN /Sqm (10kN/Sqm for drains) shall also be considered. The structure shall be designed for following criteria – (a) Inside empty with outside fill+ surcharge and water table at GL & (b) Inside water with no fill & water table outside
Pre-cast and chequered plate cover over cable trench	4.00 kN/ Sqm

Primary Loads

i) Dead Load (DL)

ii) Live Load (LL)

iii) Wind Load (WL) – Both along ±X & ±Z horizontal direction

iv) Seismic Load (EL) – Both along ±X & ±Z horizontal direction

To calculate the design wind speed (Vz), the factors K1 (probability factor or risk coefficient), K2 (terrain roughness and height factor) and K3 (topography factor) shall be considered as per IS 875 (Part-3) (However, minimum values for K1, K2 and K3 shall be .94, 1.0 and 1.0 respectively).

Topography factor 'k3' shall be taken as 1.0 upto upwards slope of 3°. For topography with upward slope greater than 3°, the value of 'k3' shall be calculated as per Annexure- C of IS 875 (Part-3).

To calculate the design wind pressure 'pd', factors 'ka' (area averaging factor) and 'kc' (combination factor) shall be taken as 1.0.

The Seismic Load shall be considered corresponding to earthquake zone at site as per IS: 1893 (Part- 4) with Importance factor 1.5. Ductile detailing as per IS 13920 shall be followed in concrete structures except in case of concrete support structure upto plinth level supporting open installations of inverters, transformers and control panels at ICR/LCR, wherein the detailing shall conform to IS 456 and SP 34.

Notes for <u>MMS Design</u>

WL shall be considered as detailed below for estimation of WL under primary loads:

(i) WLx (downward), WLz (downward): Load due to positive pressure on design tilt angles of MMS members for wind acting in both (±X, ±Z) directions.

(ii) WLx (upward), WLz (upward): Load due to negative pressure on design tilt angles of MMS members for wind acting in both (±X, ±Z) directions.

(iii) WLx (member load), WLz (member load): Load due to wind action on side (exposed) face of respective MMS members (drag force) for wind acting in both (±X, ±Z) directions.

- ±WLx (member load, transverse to MMS table): Load due to wind action of column, front and back bracing, longitudinal bracing.
- ±WLz (member load, along length of MMS table): Load due to wind action of column, rafter front and back bracing, longitudinal bracing

For estimation of design wind loads on purlins (Table 8 of IS 875- Part 3), WL (downward) and WL (upward) on modules (laid in the profile of mono slope canopy) shall be applied such that the center of pressure should be at (0.3 × length of canopy) from windward end (for simplicity, the wind load distribution may be taken as triangular with max. value at windward end). Solidity ratio (ø) shall be taken as 0.5.

In design of MMS (for height of structures less than 10 m from ground), 20% reduction in wind pressure as per Note under Cl. 6.3 of IS 875 – Part 3 is not permitted in case of purlins (members supporting modules), which shall be designed against action of WL corresponding to full wind pressure.

<u>Design Load combinations</u>

Appropriate Load factors in LSM design for concrete structures and appropriate Factor of safety in WSM design (ASD) for all steel structures including MMS shall be considered as per relevant IS standard. No increase in permissible stress is permitted in design of MMS.
Following load combinations shall be considered in design:

- For MMS Design:
  (i) DL+LL
  (ii) DL+LL ± WLx (upward) ± WLx (member load)
  (iii) DL+LL ± WLx (downward) ± WLx (member load)
  (iv) DL+LL ± WLz (upward) ± WLz (member load)
  (v) DL+LL ± WLz (downward) ± WLz (member load)
  (vi) DL+LL ± ELx
  (vii) DL+LL ± ELz
- For RCC and Steel structures except MMS:
  (i) DL+LL
  (ii) DL+LL ± WLx
  (iii) DL+LL ± WLz
  (iv) DL+LL ± ELx
  (v) DL+LL ± ELz

  All structures and foundations shall be designed to withstand loads corresponding to worst design load combination.

3.10.14 **Foundations (General)**

Contractor shall design all foundations for MMS, BESS, containers & other structures as per relevant international standards and recommendations of Geotechnical investigation report.

No foundation for MMS, containerized transformers, etc. shall rest on filled-up ground. However, minor structures like cable trench, cable rack, pipe pedestal, etc. may rest on filled-up soil with max. safe bearing capacity for design considerations as per geotechnical investigation.

Min. depth of foundation for all plinth for open installations shall be as per geotechnical investigation. For all other structures, min. depth of foundation shall be a per soil investigation unless specified otherwise.

All design & drawings shall be submitted to the Engineer for approval before execution.

No separate payment for design shall be paid by the employer.

3.10.15 **Concrete Works**

General requirement

a. Work covered under this Clause of the Specification comprises the design, drawing and construction of foundations and other RCC constructions for switchyard bus supports, equipment supports, cable trenches, Joint Pits, Cable Bridges, RCC retaining wall, or for any other equipment or service and any other foundation required to complete the work. This clause is as well applicable to the other RCC constructions.

b. Concrete shall conform to the requirements mentioned in relevant British standard codes (B

S Codes)/ equivalent International Standards. And all the tests shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards. However, M20 (design Mix) concrete shall be used for all structural members as per relevant British standard codes (B S Codes)/ equivalent International Standards.

c. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.

d. If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre-cast or under reamed type as per relevant parts of relevant British standard codes (B S Codes)/ equivalent International Standards. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the contractor showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

e. The Contractor will be required to remove and replace at his expenses any materials incorporated in the work that do not conform to these Specifications.

f. The Contractors shall provide without extra cost all materials, which may be required for testing. The cost of the tests shall be borne by the Contractor.

Reference to standard specifications

Standard referred to in these specifications are as follows.

a) BS/IS/ASTM/Equivalent international standards refer to the latest edition of publications for materials.
b) BS/IS/ACI/AISC/Equivalent international standards refer to the latest edition of publications for design of structures and foundations.

Concrete

(i) At least on month prior to the placement of any concrete, the Contractor shall test cubes/cylinders for each trial mix under both field-cured and laboratory cured conditions. The test cubes/cylinders shall be made and tested in accordance with the applicable standards.
(ii) The concrete mixes be of such proportions as to produce a plastic and workable mix which will not separate during placing and will finish sell without using excessive quantities of mixing water.
(iii) After the test results are known for the test cubes/cylinders, the Contractor shall submit test result to Owner/Engineer then Owner/Engineer will notify the Contractor of the acceptable design mixes.

Cement, Coarse & Fine Aggregate

(i) In locations where, in the opinion of the Owner/Engineer, the conditions required the use of high sulfate resistance cement, conforming to the requirements of ASTM C150 type V/Equivalent IS standard shall be used without any extra cost to the Owner.

(ii) The aggregates shall consist of clean, crushed materials or, subject to the approval of the Owner/Engineer, manufactured aggregate may be used.

(iii) Aggregates shall be separated into sand and coarse aggregate before being used. No pit or crusher run materials will be permitted without prior approval of the Owner/Engineer.

(iv) All cement, coarse and fine aggregates shall be as per the relevant codal and Field Quality Plan requirement.

Storage of materials

Cement and aggregate shall be stored at the site of the work in a clean condition and should not become contaminated with undesirable substances. Special care shall be taken in storing cement to keep it thoroughly dry at all times.

(i) When reinforcing steel is procured to the store yard in advance of the Contractor's requirements, the Contractor shall provide suitable protection in order to prevent excessive rust developing on the reinforcing steel. It will be Contractor's responsibility to remove excessive rust.

(ii) Before starting of the foundation construction all screened aggregates and sand shall be collected and stockpiled near site. So that it is free from clay, dust and other foreign materials.

Concrete mixing

(i) Before any concrete mixing is begun all equipment for mixing, transporting and placing the concrete shall be cleaned of all dirt and debris. All dirt and debris shall also be removed from the places to be occupied by the concrete.

(ii) All mechanical equipment shall be checked before starting a concrete placement to ascertain whether it is in good operation condition, repaired or replaces to the satisfaction of the Owner/Engineer.

(iii) When a foundation location is ready for concrete placement, the Contractor shall inform Owner/Engineer before concrete placing time so that Owner/Engineer may inspect to assure that the excavation is free of water, mud and debris; that the bottom surface of the excavation is a well levelled and properly dressed; that the reinforcing steel is properly secured in place; and that the formwork is properly braced.

(iv) Rock surface shall be as flat as possible and projecting ridges shall be levelled off before the concrete is placed or space between the ridges shall have been filled with concrete to form a horizontal surface.

(v) The Contractor shall ensure that all materials that is to be embedded in the concrete has been placed before pouring of concrete. The contractor shall be responsible for the accurate location of all embedded materials. Any work in accurately or improperly set shall be relo-

cated and rest reset at the Contractor's expense.

(vi) All batching components of the concrete shall be accurately measured. In case of design mix concrete, all components of concrete shall be measured by weight. In case of nominal mix, the components of concrete are measured by volume. Volume measurements shall be made in standard measuring boxes.

(vii) A mechanically operated batch mixer shall be used for concrete mixing.

(viii) The re-tempering of concrete, which has partially hardened, that is remixing with or without additional cement, aggregate or water, will not be permitted.

(ix) Concrete shall be conveyed from the mixer to the place of final deposit within 30 minutes by methods which will prevent the segregation or loss of the materials. After 30 minutes of mixing the mixed concrete shall be rejected and replaced by fresh concrete at contractors own expense.

(x) Equipment for chuting, pumping and pneumatically conveying concrete shall be of such size and design as to insured a practically continuous flow of concrete at the delivery end without separation of the materials. The chutes shall never be on a slope that is steeper than two vertical to three horizontal.

(xi) When the Concrete is to be placed on hard rock or other concrete, after the existing surface has been properly cleaned and otherwise prepared the existing surface is to be wetted until it is saturated. The cement slurry shall be evenly spread on the water- saturated surface and then normal concrete shall be deposited continuously and as rapidly as practicable.

(xii) The concreting shall be carried on at such a rate that the concrete is at all times plastic and flows readily into the spaces between the bars and so that each layer properly mixes with its predecessor. Successive layers shall be places within 15 minutes of the preceding layer.

(xiii) When placing concrete with free drops over 1.5 meters, sufficient numbers of hoppers and trunk must be provided of a size to allow for proper placing. The trunk sections shall reach within 500mm of the bottom of the placement.

(xiv) The concrete shall be consolidated during and after depositing by vibration, the concrete shall be thoroughly worked around reinforcement and embedded items and into corners of forms.

(xv) The Contractor shall always have at least two vibrators in operating condition at the location of the concrete placement.

(xvi) Vibrators shall not be used to transport concrete inside the forms.

Concrete Testing

(i) The contractor shall complete concrete testing as per the approved FQP (to be submitted and finalized before start of work). There shall be three cubes/cylinders to a set and the cubes/cylinders shall be made in accordance with relevant codes.

(ii) The Contractors shall deliver cubes/cylinders to a location of approved lab by the Owner/Engineer where they will be tested in accordance with BS/IS/ASTM C39/ Equivalent international standards.

(iii) The Owner/Engineer will determine what remedial measures are necessary and the Contractors shall perform the remedial measures at his own expenses. The remedial measurements may include, but are not limited to, the replacement of the entire foundation; The Contractor shall also pay for any additional concrete tests including core drilling and the repairs or replacements which may result from same, which the Owner/Engineer deems necessary strength.

(iv) The cost of the tests for all materials, concrete cubes will be borne by the Contractor. No additional payment shall be made in this regards.

Concrete formwork

(i) Forms shall be used, wherever necessary to confine the concrete for structures and shape it to the required lines or to avoid contamination of the concrete by materials caving or sloughing from adjacent surfaces by excavated material.

(ii) Forms shall be provided with tie rods and clamps to have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and shall be maintained rigidly in position. Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Molding strips shall be placed in the corners of forms so as to produce chamfered edges on permanently exposed concrete surfaces. All exposed surfaces shall be formed with plywood or steel sheathing. Unexposed surfaces may be formed with any materials of adequate strength and tightness to hold the plastic concrete in proper position and prevent the loss of mortar.

(iii) If plywood or steel forms are not available, the Contractor may substitute wood planking provided exposed surfaces to remove ridges.

(iv) Before concrete is placed, the surfaces of all forms shall be coated with a form oil that effectively prevents sticking and will not stain the concrete surfaces. For steel forms, form oil shall consist of refined mineral oil compound.

(v) Forms shall be removed only after 48 hours of concreting or when the strength of the concrete is such that form removal will not result in cracking, spalling, or breaking of edges of surfaces, or other damage to the concrete. Any concrete damages by forms shall be repaired immediately.

Concrete finishing and curing

(i) The exposed top surface of all concrete foundation piers shall be properly finished and shall be slightly sloped to prevent the accumulation of water.

(ii) Immediately after the removal of forms, the holes left by form tie rod fastener shall be filled with mortar and all damaged or defective concrete shall be repaired or removed and replaced to the satisfaction of the Owner/Engineer. Improperly consolidated concrete shall be removed by chipping and the clipped openings or recesses shall be of such depth and shape are required to insure that the patching materials placed in the openings or recesses will be thoroughly keyed and bonded to the concrete. "Dry pack" mortar shall be used for filling relatively deep chipped recesses with small surface dimensions. Concrete will be required for the replacement of defective concrete where surface dimension of the shipped openings or recesses are relatively large. The depth of chipped recesses for concrete patches shall extend at least 25 mm beyond the nearest reinforcing steel.

(iii) To ensure proper curing, all concrete shall be kept moist for a period of a least ten (10) days. Burlap or and equivalent materials or a curing compound shall be applied over exposed concrete surfaces, the burlap shall be kept moist at all times.

Membrane curing compound

(i) Where ever there is shortage of water for curing purpose, Membrane curing compound shall be applied (as per direction of employer) by uniform spraying, leaving no pinholes or gaps, at a rate not to exceed 4.91 square meters per liter. The curing compound shall be applied after finishing operations are completed and surface moisture has disappeared. If forms are removed prior to 7 days placing the concrete, the uncovered surfaces shall be coated with the curing compound as specified herein.

(ii) Foundations shall not be backfilled before they have been inspected by Owner/Engineer to see that they are free from surface defects and voids, or that the defects and voids have been properly repaired.

(iii) The foundations shall not be subjected to any loads in addition to those existing at the time of placing of the foundation concrete until the curing period has elapsed.

Grouting

Grouting for seating structural steel members and equipment on foundations shall be non-shrink (not-setting) Portland cement mortar grout or a suitable commercially available grout, at the Contractor's option. Grouting shall be done under pressure by means of an expanding agent or by means of static head. Propositioning and missing of grout shall conform to the following:

(i) Mortal grout containing aluminium powder as an expansive agent mixture of 1 part cement and 2 parts sands, by weight, with a water cement ratio not exceeding 0.55 the quantity of aluminium powder used shall be approximately. 0.005 percent of the weight of cement, the actual quantity to be determined from tests with materials to be used, and at the temperature and under the conditions of a placement. Aluminium powder shall be blended with cement in proportions of one part powder 10-50 parts cement, by weight and the blend shall be sprin-

kled over the dry batch. After all ingredients are added, the batch shall be missed 3 minutes. Grout, which has not been placed within 45 minutes, shall be wasted.

(ii) In lieu of use of an expensive agent. Settlement shall be reduced by extending the missing period or by delaying final mixture to minimize the interval between time to placement and initial set and placement the under static header pressure. The motor grout shall be mixture of one part cement and 2.5 parts sand, with a water cement ratio of approximately 0.50 slump shall be the minimum necessary to enable placement.

(iii) No separate or direct payment will be made to the Contractor for Grouting. The cost of Grouting is deemed to be included in the cost of foundation work.

Payment

Payment for the contract item concreting will be made as per the price bid. Measurement of concreting works at all locations shall be made and shall include all leads, lifts, formworks, grouting of pockets and underpinning. This shall also include pre-cast RCC work and addition of water proofing compound & admixtures wherever required for which no additional payment shall be made. The quantity shall be measured in cubic meters as per lines and levels indicated in the approved drawings. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings having cross-sectional area up to 0.1 sq.m.

3.10.16 HYSD/TMT reinforcing bar

(i) All steel reinforcing bar shall conform to the requirement of IS 1786 or equivalent international standard.

(ii) Mill scale rust, oil and mud shall be removed from reinforcing steel by firm rubbing with burlap or equivalent treatment before the reinforcing steel is placed.

(iii) Reinforcing steel shall be accurately located and shall be secured in position by the use of binding wire and shall be supported in a manner that will keep the reinforcement away from the exposed concrete surfaces. Concrete blocks shall be used to support the reinforcing steel in the foundation mat: broken stones or wooden blocks shall not be used to supporting the reinforcing steel.

(iv) Payment for the contract item reinforcement steel, will be made as per the price bid. Reinforcement shall be measured in length (actual or theoretical as per drawing whichever is less) including hooks, if any, separately for different diameters as actually used in work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in tons on the basis of sectional weights as adopted by International Standards. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement

3.10.17 Brickwork

(i) All first-class brick work shall be made with first class bricks built in 1:4 cement mortar (1 cement: 4 sand). All materials must be approved by the Employer/Engineer before using in the construction work.

(ii) All the bricks used for masonry construction shall be thoroughly burnt, deep cherry red or copper in colour, regular in standard shape and size, free from cracks, emit a clear ringing sound on tapping with a steel trowel and have a crushing strength as per the Nepal Standard Brick Masonry NS: 1/2035. A brick shall not absorb more water than 15 % of its weight after 24 hours of soaking in water at normal temperatures.

(iii) All brick work shall be laid with specified mortar of good workable consistency. Cement mortar shall be prepared by mixing cement and sand in the specified proportions the mixing shall be done in a mechanical mixer or by hand mixing as directed by Employer/ Engineer. Water shall be added as required during mixing. Care shall be taken not to add more water than what is actually needed to bring the mortar to the consistency of a stiff paste. Only the quantity of mortar, which can be used within 2 hours of its mixing shall be prepared at a time. Mortar unused for more than 2 hours shall be rejected and removed from the site of work.

(iv) All bricks required for masonry in cement mortars shall be thoroughly soaked in clean water for at least one hour in tanks of sufficient size immediately before use. The cessation of bubbles when the bricks are immersed in water is an indication of through soaking of bricks.

(v) Green work shall be protected from rain by suitable covering. Brick masonry with cement mortar shall be kept constantly moist on all faces for a minimum period of 7(seven) days.

(vi) Where exposed to weather, protect top of masonry with water tied material in such a way that it will protect the completed work. Masonry wall shall set for 48 hours before any load is applied on the completed work.

(vii) The measurements of work shall be the product of the length, height and thickness. Deductions for openings lintels shall be made to arrive at the net quantity of work. Nothing shall be paid extra for forming such openings. However, no deductions shall be made for areas less than 0.05 sq.m. Unless otherwise specified nothing extra shall be admissible for cutting in brickwork or brick to suit RCC structures, walls in any shape other than straight or any cutting necessary for shaping the walls to the structural design. Rate shall be inclusive of providing weep holes of PVC pipes (if any) and all necessary scaffolding, watering, cutting of bricks, curing, materials and labour.

3.10.18 Stonework

All stone work shall be made with random rubble stone from the best quarry and built in 1:4 cement mortar (1 cement: 4 sand) and fixing of required weep holes for substructures. The stones must be approved by the Employer/Engineer before using in the construction work.

(i) The stone shall be hard, tough, sound and durable. Stone shall not be less than 15 cm and more than 45 cm. Face stones shall be larger and uniform in size and colour to give a good appearance. Breadth of face stones shall be greater than the height. Face stones should tail into wall to a sufficient depth to bond well. Stone shall be laid with broader face downwards to give good bedding. Face joints shall be broken and face of wall shall be truly in plumb. Corner stone or quoins should be of good stones and dressed correct to angle and laid as headers and stretchers. All stones shall be wetted thoroughly before laying.

(ii) The rubble stone shall be placed with 1:4 cement sand mortar after having joints thoroughly moistened. The surface joints shall be finished by flush pointing with 1:2 cement sand mortar. The ingredient shall be accurately gauged by measure and shall be well and evenly mixed together in a mechanical plant mixer care being taken not to add more water than is required. No mortar that has been set shall be used. River sand shall be used unless otherwise specified. If hand mixing is allowed then it shall be done in masonry tanks. The gauged materials shall be put on the platform and mixed dry. Water will be then added and whole mixed again until it is homogeneous and of uniform colour. Mortar shall be prepared in such quantity, at one time, which shall be consumed within half an hour of its mixing. The work shall be well watered for a fortnight.

(iii) Joints shall not be thicker than 19 mm. Face joints shall be thinner. Interstices, if any may be filled with pieces of spalls of stones embedded in mortar. In the corners, the stones should be chiseled at both sides and also on the top of the stone walls where the wall is ending and such surfaces being built up. Not more than 60 cm height of masonry shall be constructed at one time.

(iv) Through bond stones of one piece shall be provided one for every 0.5 m2 (5sq.ft.) of face. For walls thicker than 75 cm bond stones may be of two pieces placed side by side over lapping at least 25 cm. Breadth of lap stones shall not be less than 1.5 times the height. All stones shall be thoroughly wetted before laying. At the end of day's work masonry shall be flooded with 2.5 cm water at the upper surface with the help of fillets of mortar about 38 mm high, made round in edges. The masonry shall be protected from sun, rain, frost and other weather effect.

(v) Measurement for payment of stone masonry works shall be made on the basis of actual volume of stone masonry in cubic meters. The measurement of work shall be the product of the length, thickness and height. Payment shall be made for the number of cubic meters measured as provided at the unit price specified in the schedule. The unit price shall include all labors, equipment, materials, fixing required weep holes, scaffolding and all other cost necessary for the performance and completion of the works.

3.10.19 **Cement Plaster Work**

Cement Sand Plastering in Cement Sand (C/S) Mortar (1:4)

(i) For plastering work, unless otherwise specified, proper scaffolding shall be provided. The Contractor shall be responsible for providing and maintaining sufficiently strong scaffolding so as to withstand all loads likely to come upon it.

(ii) The type of mortar mix to be used shall be as specified in the description of the item.

(iii) Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a minimum period of 7 days. The dates of plaster shall be legibly marked on the various sections of the wall so that curing for the specified period thereafter can be watched. Any cracks which appear in the surface and all portions, which sound hollow when tapped or are found to be soft or otherwise defective, shall be cut out in rectangular shape and re-done as directed by the Employer/Engineer.

(iv) It shall be done in square metre of the surface over which the plaster has been done. The thickness of the plaster shall not be taken into account. Opening shall be deducted in full. Openings less than 0.5 sq.m shall not be deducted and nothing extra shall be paid for finishing jambs, soffits and the sides of such openings. Unless otherwise specified, nothing extra shall be allowed for plaster on independent columns and beams, short with or on curved surface.

Cement Pointing

This specification covers supplying materials and executing the pointing works on outside of stone work.

(i) The joints of the brick work/stone work shall be raked out to a depth of 3/4" and the wall surface washed and cleaned and kept wet for two days before pointing.

(ii) Wooden ballies, planks, trestles, G.I. pipes, ply board and other scaffolding material shall be sound and erected in accordance with the specification given under Stone Work or as directed by the Construction Manager.

(iii) The materials for mortar-cement and sand as specified shall be of standard specifications as mentioned in the beginning, (see concrete works). The materials shall be first mixed by measuring with boxes to give the required proportion as specified (1:3); and then mixed by adding water slowly and gradually to give a working consistency.

(iv) The mortar shall be pressed into the raked, cleaned and wet joints and a groove of shape and size of 5 to 6 mm deep shall be formed running a forming tool of steel along the centre line of the joint. The vertical joints also shall be finished in a similar way at right angles to the horizontal lines. The finished work shall give a neat and clean appearance with straight edges.

(v) The finished work surface shall be cured for seven days and shall be protected by hanging mattings or gunny bags on the pointing keeping them wet. Curing shall be done in a way to avoid or minimize overflow or seepage to the existing surface below.

(vi) Measurement and payment shall be done in square meter as in item. Measurement shall be done nearest to two decimal places separately for various mixes of the work for the net quantity executed. All openings shall be deducted and any jambs, soffits etc. measurements shall be allowed. The rate includes all labour, materials, erection and removal of

scaffolding, preparation of background, finishing etc.

3.10.20 Slope protection / Retaining wall

Retaining wall/slope protection in gabions are to be provided for all unstable slopes in the installation area.

The stone should be hard, tough, sound, angular and durable and should be packed into the baskets taking care that there are no voids left. Size of stones should be from 10 to 20 cm maximum dimension.

For Random rubble masonry work all stonework shall be made with random rubble stone from the best quarry and built in 1:4 cement mortar (1 cement: 4 sand). The stones must be approved by the Employer/Engineer before using in the construction work

The standard type of gabion shall be a flexible hot dip galvanized gabion of the type and size specified below. It is made of wire mesh of the type and size and selvedge as specified in the following:

- The mesh shall be hexagonal woven mesh with the joints formed by twisting each pair of wires through three and half turns.
- The size of mesh shall conform to the standard specification issued by the factory and shall be not greater than 1/3 of the smallest stone filled in the gabion.
- All wire used in the fabrication of the gabions and in the wiring operations during construction shall be "mild steel wire", i.e., wire having average tensile strength of 44 kg/sq.mm.
- The diameter of the wire used in the fabrication of the netting shall be at least 3.0 mm depending on the design requirement.
- All wires used in the fabrication of the gabions and in the wiring operations during construction shall be hot dip galvanized.

All edges of the standard gabions including end panels and the diaphragms, if any, shall be mechanically selvedge in such a way as to prevent unravelling of the mesh and to develop the full strength of the mesh. The wire used for the selvedge shall have a diameter greater than that of the wire used to form the mesh. Wire having a diameter of 3.0 mm and the selvedge wire shall have diameter equal to or greater than 3.9 mm.

The stone for the gabion shall be taken from a quarry or river deposit material or as approved by the Employer or Employer's representative. The rock shall be of compact, firmly bound and uniformly grain texture and absolutely weather-resistance shall not have cracks, holes, laminations or detrimental materials. The stone blocks shall be of natural irregular cubical shape. The thin sliced blocks shall not be accepted. The sides of the gabion wall should be backfilled, compacted and levelled as directed by Engineer.

The standard gabion shall have the following dimension:

Length: 2.0 m; Width: 1.0 m; Height: 1.0 m

Sufficient connecting wire shall be supplied with the gabions for all the wiring operations to be carried out in the construction of the gabion work. The quantity of such wire is estimated to be 8% of the gabion supplied. The 2.4 mm lacing wire shall be used for the gabion made of wire gauge 3.0 mm.

Geotextiles. Geotextile shall be used in inside of rationing/gabion wall for sub-surface drain of water. Geotextile used for sub-surface drains shall be made of polyethylene or polypropylene or polyester or similar fibers, either woven or nonwoven. Unless otherwise shown on the construction drawing, the geotextile shall:

- Sustain a load of not less than 10 kN/m at break and have a minimum failure strain of 10 percent when determined in accordance with BS: 6906 or shall have a grab tensile strength more than 0.4 kN/m and grab elongation corresponding to this limit in accordance with ASTM D4632.
- Have apparent opening size as shown on the Drawing. If no size is shown on the Drawing, then the apparent size shall be 0.1 mm.
- Allow water to flow through it at right angles to its principal plane, in either direction at a rate of not less than 50 litres/sq.m./sec. under a constant head of 100 mm, determined in accordance with BS: 6906 (Part 3) or ASTM D4491, unless otherwise shown on the Drawing. The flow rate determined in the test shall be corrected to that applicable to a temperature of 15 °C using data on variation in viscosity of water with temperature.
- Have a min puncture resistance of 200 N when determined in accordance with ASTM D 4833.
- Have a min tear resistance of 350 N when determined in accordance with ASTM D 4533.

3.10.21 Fire Fighting and Detection System

The Solar PV plant shall be equipped with suitable fire protection and fighting systems for entire PV array area. Firefighting provisions for containers to be as specified.

Automatic fire detection cum alarm system shall be provided in all modular unit control rooms. Fire detection and alarm system shall be integrated with required cabling to a single fire alarm control panel. Fire detection alarm system shall include alarm initiating multi sensor type smoke detectors. The entire system shall work on auxiliary power supply.

The solar plant facilities must be equipped with LiquefiedCO2/ foam/ ABC type fire extinguisher of capacity 10kg conforming to IS: 2171, IS: 10658. Further for containers it should as specified.

FIRE ALARM SYSTEMS	
Addressable fire alarm system	The fire alarm system includes the fire control panel, smoke detector, heat detector, fire alarm bell, and fire alarm horn strobe. The automatic fire extinguishing system uses the total flooding extinguishing mode and includes the fire control panel, manual emergency start/abort switch, gas extinguisher (including the fire cylinder, extinguishing agent, electromagnetic valve, pressure gauge, and pneumatic switch), fire control pipes (pipelines and high-pressure hose), nozzle, and gas release indicator.
Aspiration smoke detection system	Supply, Installation, Testing & Commissioning, calculations of flow and hole sizes in pipe network. Sampling unit shall be of LED technology. Detected smoke density shall be able to be adjusted between high sensitivity to equal as ordinary smoke detector. Sampling system is connected to loop for ordinary fire alarm via address unit. Operation of sampling unit and status shall be able to display in fire alarm central unit.

3.10.22 Sign Boards and Danger Boards

The sign board containing brief description of major components of the power plant as well as the complete power plant in general shall be installed at appropriate locations of the power plant as approved by Engineer.

Safety signs, assembly points, high voltage sign boards etc. shall also be placed at strategic locations.

3.10.23 PV Module Cleaning System, Water Supply, Drainage & Sanitary, Septic Tank, Soak Pit, Manhole &

The contractor shall design and install an effective PV module cleaning system. A regular supply of suitable quantity of water shall be ensured by the contractor to cater day-to-day requirement of drinking water, bathroom uses and for cleaning of PV modules.

Contractors shall study the site topography and plan the surface drains accordingly. Utmost care shall be taken to maintain slopes and to prevent water clogging at the site. Proper water drain channels with RCC Hume pipe culverts shall be designed wherever necessary. These works should be designed for 25 years.

The water supply shall be for cleaning of PV plant, drinking and other sanitary uses, use in the guard house and control room as appropriate. Further, sufficient head has to be designed by placing water tank at an appropriate elevation. Moreover, appropriate pipes and fittings are to be supplied and constructed to enable proper water to flow in the above designated areas.

The Contractor shall carry out survey for the detail plan for the sanitary installation and drainage installation for approval to the Employer/ Engineer. The Contractor shall ascertain the Employer/ Engineer about the approximate level of subsoil water and flood level in relation to the sewer system. Any drainage system be designed and produced for approval to the Employer/ Engineer.
Where no method of disposal is possible, foul water may be collected and dispersed into subsoil, the general sub-soil water level and the sub-soil conditions shall be ascertained including the absorptive capacity of the soil.

If the sub-soil dispersed or soak pit system would be followed, the pit shall not be in the vicinity of water supply source at least by 50 m.
The efficient and adequate system shall be proposed by the Contractor for approval of the Employer/ Engineer.

The septic tank shall be with brick masonry in 1:4 cement mortar, the foundation and floor shall be of M20 concrete. Inside shall be finished with 20 mm cement plaster 1:4 with 1:1 cement smooth punning or as per drawing.

The covering slabs and baffle wall shall be of R.C.C. of M20 with sufficient reinforcement.
The length of connecting pipe shall depend on the location of septic tanks as per direction. The connecting pipe shall not be less than 10cm diameter of UPVC.

Payment of septic tank shall be done according to the quantities measured as per Bill of Quantities. But payment for pipe works shall be included on lump sum works of sanitary works.

Soak pits shall be of two numbers one separate for the staff quarter building and one common for the guard house and store building constructed with brick masonry in 1:4 cement sand mortar with honeycomb and filled with at least 7.5 cm size brick bats or as per drawing and as directed by the Employer/ Engineer.

The upper portion of the lining up to the inlet valve at least 45cm in height should be made with masonry in mortar cement 1:4 for strengthening, for preventing surface water to enter into the pit and to prevent rat throwing earth into the pit. The inlet pipe shall be fixed in the wall of the pit with mortar. The pit shall be covered with R.C. slab of M20 with necessary reinforcement. The absorption area of sock pit shall depend on the nature of soil type and underground water table. The Contractor shall propose the depth and soak area and location of tanks depending on the number or users, type and nature of soil water table.

Payment of soak pit works shall be done according to the quantities measured as per Bill of Quantities. But payment for pipe works shall be included on lump sum works of sanitary works for each building.
The manhole shall be made as per requirement and direction. The manhole shall be made with brickwork in 1:4 cement mortar concrete base, 12mm plaster with 1:4 cement smooth punning.

The cover shall be of heavy duty metallic and double sealed, complete with painting. The manhole frame bedded in cement mortar shall be given recessed for lifting hooks.
Payment of manhole works shall be done according to the quantities measured as per Bill of Quantities. But payment for pipe works shall be included on lump sum works of sanitary works for each building. The above-mentioned sanitary and drainage structures shall be as per drawing direction and approval of the Employer/ Engineer.

3.10.24 Lightning Protection System

- The entire solar PV+BESS plant area including all containers shall be protected from lightning. The protection system will be based on early streamer emission lightning conductor air terminals. The air terminals shall provide an umbrella protection against direct lightning strike covering a radial distance of maximum 60 m. The air terminal will be capable of handling multiple strikes of lightning current and should be maintenance free after installation. Essentially the Lightning Protection System equipment shall be installed in accordance with IEC 62305.
- The earthing stations for the lighting discharges shall be provided with test links of phosphorus bronze and located at 150 mm above ground level in an easily accessible position for testing.

3.10.25 Boundary Fencing

- Boundary fencing must be erected around the periphery of the Solar PV + BESS plant at each site except for site at Mugu to ensure safety of the plant from trespassing.
- An iron mesh boundary wall with angle iron post and barbed wires must be erected. An entry gate must also be provided. The gate must have a plain grill design with two coats of primer all complete as per approved design.

- Preferably 60x60x4 mm size galvanized angle iron post with primer @2.5 m c/c including 10SWG.I chain link of 2"x2" between iron angle with 3*50 mm iron plate patti including nuts and bolts connection as per approved design must be used.
- Heavy coated 12 SWG GI Barbed wire in the angle iron post must be preferably provided. The contractor must submit the design of the fencing to the employer for approval.

3.10.26 Electrical Installation

All electrical works installation shall be safe, simple, in a systematic order so that a general electrician can easily solve the problem arises during the maintenance of the system.

The quoted bid rates shall include for the layout design, cost of material, installation, connection, testing and commissioning, supervision, transport, tools, breakage, wastage, sundries, scaffolding, and maintenance of installation works for guarantee period of one year and all other works associated to complete the project.

3.10.27 FQP: Field Quality Plan

(i) The material specification, workmanship and acceptance criteria and Contractor shall execute the work as per the approved Field Quality Plan.

(ii) The standards used may be BS/IS/ equivalent international standards.

(iii) Contractor shall submit the FQP for approval before commencement of works.

(iv) All testing required as per the approved FQP shall be arranged by the Contractor at his own cost including frequency tests also.

3.10.28 Interfacing

The proper coordination & execution of all interfacing civil works activities like fixing of foundation bolts, fixing of supports/embedment, provision of cut outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is reduced to minimum.

3.10.29 Finishing Schedule

BUILDINGS

All buildings shall be constructed as per latest Nepal Building Code (NBC) standard/as provided in the tender document. The design of the building shall match with local architecture and relevant standards. The plumbing and sanitary works including availability of water from source to the building shall also be deemed to be included in the civil works of the building along with the required electrical works. These works shall not be measured and paid separately.

Table- 1: DETAILED FINISH SCHEDULE

Sl. No.	LOCATION	FLOORING AND SKIRTING 100 MM HIGH	WALL(INTERNAL)	CEILING	REMARKS
Guard House (Floor Height = 3 meter clear)					
1.	Resting Room	Plaster punning (3mm) over 38mm concrete screeding (1:2:4)	Two coats washable distemper paint over one coat primer	Two coats washable distemper paint over one coat primer	
2.	Kitchens	Plaster punning (3mm) over 38mm concrete screeding (1:2:4)	Two coats washable distemper paint over one coat primer	Two coats washable distemper paint over one coat primer	Double Charged Tiles over counter slab and Porcelain Glazed Tiles on wall around counter Slab. Wash Basin with tap.
3.	Bathroom	Porcelain Glazed Tiles Flooring and Skirting upto lintel	Two coats washable distemper paint over one coat primer	Two coats washable distemper paint over one coat primer	One Urinal, One Indian Style Pan, Wash Basin, and other fixtures as applicable
4.	Verandah	Plaster punning (3mm) over 38mm concrete screeding (1:2:4)	Two coats washable distemper paint over one coat primer	Two coats washable distemper paint over one coat primer	
5.	External Plasters	Petty min. 600 mm thickness with Plaster punning (3mm) over 38mm concrete screeding (1:2:4)	Two coats weather apex coat paint over one coat primer (Jumla, Mugu, Dolpa) Flushed Ruled Pointing (1:2): Humla Site		
6.	Roof Top	Plaster punning (3mm) over 38mm concrete screeding (1:2:4)			
7	Opening Schedule	Doors: Wood Panel Doors with Sal Wood Frame; Enamel Paint finish Windows: Wood Panel Window with Sal Wood Frame, Enamel Paint Finish			
Store Building (Floor height = 3.5 meter clear)					
1.	Internal Finishing	Plaster punning (3mm) over 38mm concrete screeding (1:2:4)	Two coats washable distemper paint over one coat primer	Steel Roof Truss with CGI Sheet (Medium Gauge), Enamel Paint Finish	
2	External Plasters	Petty min. 600 mm thickness with	Two coats weather apex coat paint over one coat primer (Jumla, Mugu, Dolpa)		

Sl. No.	LOCATION	FLOORING AND SKIRT-ING 100 MM HIGH	WALL(INTERNAL)	CEILING	REMARKS
		Plaster punning (3mm) over 38mm concrete screeding (1:2:4)	Flushed Ruled Pointing (1:2) : Humla Site		
3	Opening Schedule	Ventilations : Glass Ventilation with Sal Wood Frame, Enamel Finish Shutter : Collapsible Rolling Shutter with Enamel Paint Finish			

3.11 Commissioning and Onsite Acceptance Tests

Prior to delivery of the project, the Bidder must perform a series of onsite tests to verify the proper performance of every system.

The onsite test will be divided per individual systems: PV plant and control system. After performing the tests per each system, it will be performed for the entire solar PV + BESS plant.

Commissioning tests effectively place responsibility for system or component performance on the contractor. The commissioning tests are the responsibility of the contractor.

All the tests shall be properly documented and checked by the Project Management Team prior to the delivery of the project.

Tests shall be made on the functioning of solar panels, and respective electrical components, isolators and circuit breakers, metering, earthing, bonding, and operation of the data-logging system and monitoring.
The objectives of the tests are the following:

- Verify that the power plant is structurally and electrically safe
- Verify that the power plant is structurally and electrically robust to operate for the specified lifetime of a project
- Verify that the power plant operates as designed and its performance is as expected

- The following equipment (not limited to) shall be used during the commissioning process and are to be made available by the contractor at site without any additional cost to the employer:
  - Earth resistance tester
  - IV curve tracer
  - Insulation tester
  - Digital multi-meter
  - Clamp meter
  - Infrared (IR) camera
  - Digital lux meter
  - Electroluminescence (EL) camera, power supply and accessories
  - PV string open circuit voltage test equipment
  - Sound measuring equipment

All testing equipment shall comply with relevant IEC / EN / UL standards.

The tests shall be conducted under stable weather conditions.

Soiling losses shall not be accounted for in the assessment of Results. Therefore, adequate Module cleaning exercise shall be undertaken prior to commencement of Commissioning process

The completion certificate referred to in GCC Subclause 24 will be issued subject to the equipment meeting the standards and acceptance criteria mentioned in the following sections. The payment schedule linked to issuance of completion certificate as mentioned in schedule 1,2 & 4 under Section 9 (Contract Forms) sub-section Payment Terms will be followed accordingly.

The procedure for the commissioning and onsite test of the PV plants shall include at least the items summarized below. Further, the detail commissioning plan is to be submitted by the contractor and shall only be effective after approval by the employer.

- Gathering and review of information (technical specifications and as-built electrical plans).
- PV modules visual check.
- Mounting structure visual check.
- String combiner boxes inspection (enclosure quality, internal isolators, cable glands and labelling, etc.).
- Cable inspection for insulation resistance. If any cable is found to be faulty, they shall be immediately replaced at no additional cost to the employer.
- Cabling earthing and earth faults.
- Array tests (measurement and record solar irradiance and string/array IV curves)
- Inverter's test (commissioning procedure provided by the supplier).
- Containerized Battery test
- Grounding and earthing test
- PV string open circuit voltage test to assess string performance. The test shall be performed during daytime for good irradiance. Results shall be within 5% of Voc- expected and 5 % of all similar adjacent strings.
- I-V curve testing for 5% of overall PV module strings. The test shall be performed during daytime for good irradiance.
- IR (infrared) inspection. The test shall be performed during day time for good irradiance. Altitude angle and resolution shall be sufficient to detect hotspots within photovoltaic cells of PV modules and PV connectors. Any "hotspot" areas on PV modules shall be determined to be faulty and such PV modules shall be immediately replaced at no additional cost to the employer.
- Sound level test once before energizing the plant and one after energizing the plant.

3.11.1 Cold Commissioning: Testing of the PV Plant

The verification of the Commissioning tests will be based at least on IEC 62446-1, 2016: 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
- Support structure foundations
- String cabling
- LV DC cabling
- String combiner boxes
- Inverters
- 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
- Meteorological stations and monitoring system
- Low-voltage installation, civil works, and medium-voltage installation (if applicable)
- All measurements as defined and described in IEC 62446

The Cold Commissioning tests shall include the measurement of 100% of the open circuit voltage (Voc) of the PV module strings. The minimum irradiance on the plane of array for the Voc measurements is 600 W/m².

A report with the measurement results of all strings will be presented by the Contractor in digital form as an Excel file. Strings which show a deviation from the mean value of the measured strings by more than 10% shall be highlighted in the report. Counter measures will be coordinated with the Employer.

3.11.2 Hot Commissioning: Testing of the PV Plant

Once the PV Plant is energized (this may require a dump load during testing), the Bidder shall demonstrate that the overall system and equipment operates in accordance with the following:

- Equipment manufacturer specifications
- Specifications of the contract
- All relevant national and international norms and standards

For Hot Commissioning testing, the following supplies and equipment will be commissioned / tested:

- DC operating current tests
- Inverter functionality
- Combiner boxes
- Monitoring system functionality (intern/extern)
- Meteorological station(s) if applicable
- Safety devices
- Transformer (s)
- Security System functionality
- Visual check of grounding and lightning protection system
- Visual check of MV equipment if applicable

3.11.3 Commissioning and testing of BESS and PCMS

The Bidder will provide a detailed test plan for this system separately, which shall include at least the following items:

- Visual inspection, labelling and technical specifications checking
- Power supply test.
- Test of communication with PCMS.
- Test of command sending and reception to distributed generation systems.
- Test of reception of monitoring parameters of the distributed systems
- Test of communication latency
- Several full charge and discharge cycles at rated and peak power will be carried out, or at least to the minimum state of charge expected to operate the system on a daily basis
- During charge and discharge testing process the BESS shall achieve the peak power ratings at least once per complete cycle. The duration of the peak power shall be the necessary to

archive the optimum control of the hybrid plant and will be within the values provided by the manufacturer.

- Communications between battery BMS and PCMS controller will be tested. The tests will be performed at zero, nominal and peak power ratings of the system, in order to ensure that possible electromagnetic noise will not affect the communications.
- BESS must communicate with PCMS, so it is considered essential to carry out communications tests of these subsystems separately. Communications tests shall include both the sending of control operating commands from PCMS to BESS and monitoring parameters from the BESS to the PCMS. Tests must be conducted both at zero power and at nominal power.
- The correct functioning of ancillary systems of the BESS

The functional performance onsite tests of the control algorithm will be carried out during the hybrid plant tests.

Tests performed onsite will let the provider to verify the correct operation of the BESS at the final location. The test record shall include at least measurements of battery temperatures, power electronics temperatures, current and power values achieved, possible detected alarms and any other outstanding incidents that may occur. The tests of the BESS will include at least the following features.

Mechanical completion: The mechanical completion checking will consist of the following:

- The battery power output is properly connected to the Battery Inverters.
- Communications wiring between the Batteries and Battery Inverter and Main Power Plant Controller is correctly connected.
- No mechanical damages exist.

3.11.4 Codes and Standards

The Testing and Commissioning Procedures shall, in general, comply with the following standards:

i. IEC 62446 standard (Part 1: Grid connected systems – Documentation, commissioning tests and inspection).
ii. IEC 60364-6:2016 - Low voltage electrical installations - Part 6: Verification.
iii. IEC 61829:2015: Photovoltaic (PV) array - On-site measurement of current-voltage characteristics.
iv. IEC 60904-4:2019 Photovoltaic devices - Part 4: Reference solar devices – Procedures for establishing calibration traceability
v. IEC TS 60904-1-2:2019 - Photovoltaic devices - Part 1-2: Measurement of current voltage characteristics of bifacial photovoltaic (PV) devices
vi. IEC 62305-3– Protection against lightning - Part 3: Physical damage to structures and life hazard
vii. IS/IEC 61557: Part 2: 2007 - Electrical safety in low voltage distribution systems up to 1000 V ac and 1500 V dc - Equipment for testing, measuring or monitoring of protective measures: Part 2 insulation resistance

3.12 Functional Guarantee Tests

As part of plant commissioning process, the contractor must also conduct functional guarantee tests, in addition to the commissioning tests mentioned in section 3.11 of this document. The details of the functional guarantee tests to be performed are detailed in sub section 3.12.2 below.

To seek operational acceptance of the Solar PV + BESS plants at all four sites, the contractor must conduct functional guarantee tests within 30 days of completion of plant commissioning, and commencement of operation, and must exhibit that the functional guarantee parameters laid out by the contractor, in Form FUNC[5], are met.
Same tests will be also repeated at the end of the SLA period of 3 years to ensure that the functional guarantee parameters continue to be met.

The Contractor will be responsible for all testing, analysis and reporting.

If, during the first guarantee tests, the functional guarantees mentioned by the contractor in form FUNC are not met, then the payment due upon operational acceptance[6] of the plant will not be released to the contractor.
The contractor will be required to, at his own expense, over the course of the next three years, fix the issues that may be leading to the plant not attaining the required guarantee numbers.

Similar functional guarantee tests will be conducted at the end of the 3 (three) year Service Level Agreement period to ensure that the functional guarantees are being met by the plant. During this round of testing if the plant meets all the functional guarantee parameters, all payments due shall be released as per terms and procedures of payment.

However, if the plant doesn't meet the functional guarantees as committed by the contractor, liquidated damages will be applicable and the balance amount will be released as per terms and procedures of payment. The rate at which liquidated damages will be applicable are mentioned below in section 3.12.1.
In the scenario where the plant doesn't meet functional guarantees at the time of the second test, two cases may exist:

Case 1: The plant had met all the guarantee parameters during the first test.
In this case liquidated damages will be first deducted from the payment due upon successful completion of the 3-year SLA period[7]. If the liquidated damages exceed this amount, then they will be deducted from the contract performance guarantee.

Case 2: The plant did not meet the guarantee parameters during the first test.
In this case the liquidated damages will be first deducted from payment due upon operational acceptance, then from the amount due upon successful completion of the 3-year SLA period. If the

[5] Vol 1. Section 4: Bidding Forms
[6] Vol 1, Section 9: Contract Forms, Appendix 1: Terms & Procedures of Payment
[7] Vol 1, Section 9: Contract Forms, Appendix 1: Terms & Procedures of Payment

liquidated damages exceed the summation of both those amounts, then they will be deducted from the contract performance guarantee.

Performance in either test shall not be less than the minimum requirements, defined in functional guarantees of the facilities in sub section 1.3.4 of section 3 of vol 1 of the bid document, on any site. Any identified performance below minimum requirement level may be treated as a defect and in such a scenario the employer may consider terminating the contract as per GCC sub clause 28.2 Functional Guarantees.

3.12.1 **Liquidated Damages**

1. Functional guarantees for BESS are as follows:

Production measure	**Unit**	**Specified level***	**Rate of liquidated damages per 1% or part thereof that the measured performance is below the specified level**
1. BESS Service life	Years	8	0.8% of contract sum
2. Continuous power at point of BESS connection to grid	MW	As specified per site	0.8% of contract sum
3. BESS round trip efficiency (%)	%	85	0.5% of contract sum
4. BESS availability (%)	%	96	1% of contract sum

*Note: The values indicated in the table are indicative minimum requirement values, however for the purpose of calculating liquidated damages, the values quoted by the contractor in form FUNC under section 4 bidding forms of vol 1 will be used.

2. Functional guarantees for Solar PV plant are as follows:

Production measure	**Unit**	**Specified level#**	**Rate of liquidated damages per 1% or part thereof that the measured performance is below the specified level****
1. Availability Factor	%	94	1% of contract sum
2. Degradation Factor	%	2.5% for first year	0.4% of contract sum for first year
		0.6% for every subsequent year	0.5% of contract sum
3 Power Transformer	%	Full Load Loss: 1% of transformer capacity	0.1% of contract sum
	%	No Load Loss: 0.1% of transformer capacity	0.1% of contract sum

#Note: The values indicated in the table are indicative minimum requirement values, however for the purpose of calculating liquidated damages, the values quoted by the contractor in form FUNC under section 4 bidding forms of vol 1 will be used.

** Liquidated damages indicated are for every 1% deviation from functional guarantee. Thus, if on testing a value is found to deviate by 2% then 2X of LDs indicated in the table will be applicable and part thereof.

3.12.2 **Guarantee Tests**

Each of the BESS Functional Guarantees shall be tested using the relevant method from IEC 62933-2. Continuous Power, Energy Storage, and Round-Trip Efficiency shall be tested as a pre-requisite for Completion.

1. **Service Life** is the period during which the BESS can meet all performance requirements of this specification. Service life provides a measure of degradation in battery module performance, which will be assessed by comparing performance test results at commissioning and subsequent repeat tests against the Contractor's design degradation profile.

   To calculate Service life, ratio of Energy Storage to the energy storage degradation curve provided with the contractor's bid at completion and after year 1 of operation shall be linearly extrapolated over time. The time at which the product of this ratio and the corresponding energy storage degradation curve provided with the contractor's bid no longer meets the Functional Guarantee is the expected service life.
   In the event of underperformance of the service life guarantee, Contractor shall retest after 2 years operation (at its own cost) and recalculate expected service life using the same approach.

   Measurement tolerance for each of the tests is 1% (of the measured parameter).

2. **Round-trip energy efficiency** (RtE, η) shall be determined as a function of the charge and discharge power and calculated using the following formula:

   $\eta_p = \sum Eo / \sum Ei$

   where:

   ΣEi is the sum of Energy input to the BESS over n cycles

   ΣEo is the sum of Energy output from the BESS over n cycles

   ηp is the Round-Trip Efficiency at charge/discharge Power, P (expressed as a percentage of rated power)

   The System shall be charged to the full available energy level. Subsequently, the BESS (appropriate modular sub-unit thereof) shall be discharged and charged at rated power between the lower and upper SOC* limit (as recommended by the OEM for current application). Power during charge and discharge shall be recorded at regular intervals of time documented by the OEM to provide a statistically valid resolution. The associated energy input (Ei), including all BESS functional, parasitic and auxiliary consumption and energy output (Eo) of the BESS shall be calculated from the recorded power. Discharged energy should be recorded as per the readings in the Meter(s) installed at the point of interconnection of the BESS with the Solar PV array.
   * SOC recorded, shall be as reported by the Battery Management System.

The above process shall be repeated multiple times, with a minimum rest period between charging and discharging, if so recommended, so as to record data for a specified no. of cycles (n). The reference performance test value for stored energy shall be calculated as the mean of the values of Eo and Ei as measured for discharge and charge respectively.
The procedure shall be repeated (one cycle each) with power levels at 75%, 50%, and 25% of rated power and documented.

3. **BESS Equipment Availability** includes the availability of Batteries, Battery Management System (BMS), Power Conversion System (PCS), Energy Management System (EMS) as well as the power evacuation system for BESS up to interface with the solar PV arrays.
BESS Equipment Availability is the percentage of hours that the BESS is available during the year.

BESS annual equipment availability shall be calculated as follows.
Equipment Availability = [1 - (Σ$Accountable$ B$ESS\ Outage\ durat(hrs)\ x\ We$ / 8760) * 100]
Where:
Weightage = $Outage\ Capacity$ / $Rated\ Capacity$, where:
Outage and Rated Capacity shall be in Energy terms i.e., MWh. Rated Capacity in a given year shall correspond to the daily throughput capacity guarantee for the beginning of the year.

- Accountable BESS outages are outages caused or necessitated by the BESS equipment that result in reduced capacity or loss of essential function of the BESS. These outages may be initiated by failure of components, loss of battery capacity, operation of protective devices, alarms, or manual action. Such outages include both forced outages due to equipment problems and scheduled outages for BESS maintenance.
- Accountable BESS outage duration is the elapsed time of accountable BESS outages from the instant the BESS experiences reduced capacity or is out of service to the instant it is returned to service or full capacity. If the BESS experiences reduced capacity but is determined by the Employer to be available for service even if the Employer elects not to immediately return the equipment to full capacity, such time will be discounted from the outage duration.
- If the Plane of Array Radiation is less than 1.3kWh/m2 on a day, the day (24 hours) shall be excluded.

4. Solar PV Plant Availability Factor shall be calculated as per the following formula:

$$100 - \left\{ [1 - DF\ x\ N]\ x \left(\frac{\sum_i W_i H_i}{4380} \right) x\ 100 \right\}$$

Where,
DF = Plant degradation factor, as per Manufacturer Power Output Warranty
N = Number of years of operation after operational acceptance of the plant
W_i= Equipment weightage factor
H_i= Equipment yearly unavailability hours
4380 = Total Number of solar hours in non-leap year (average 12 hours in a day from 6am to 6pm). It shall be replaced by 4392 hours in leap year.

- Availability factor shall be calculated on annual basis from the date of Operational Acceptance of the plant.
- Availability of the following equipment along with the respective weightage factor shall be used for the calculation of availability factor. Unavailability of equipment that does not affect the plant generation shall not be considered for calculation of availability factor.

S. No.	Equipment (Ei)	Weightage Factor (Wi) per Equipment
1	HT/LT Switchgear Panel, Main Outgoing Feeder and associated Cable	1.0
2	Power Conditioning Unit and associated Cables	$\frac{\text{PCU AC Capacity}}{\text{Plant AC Capacity}}$
3	PV String and associated Cables	$\frac{\text{PV String Capacity}}{\text{Plant DC Capacity}}$

In case of outage of more than one equipment in the same path of power flow, outage of equipment with highest weightage factor shall be considered.

3.13 Documentation

The bid documentation shall describe the full system functionality, main system components, performance and parameters (data sheets), connection of existing equipment, redundancy principle, communication interfaces, the backup and recovery concepts for the PCMS, anti-virus and malware protection, and shall include the software and hardware requirements for the proposed back-up concept.

3.13.1 Documentation to be submitted with Bid

The bidder must complete all forms given in Section 4 - Bidding Forms of the Bidding Document. All of them shall be submitted electronically as PDF, Excel or Word-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 bid.

The bidder shall include a list of their sub-contractors. (If any)

3.13.2 Documentation to be submitted after contract award

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 PV Hybrid plant. The Employer reserves the right to request from the successful Bidder such additional information, drawings, documents, etc. as may be reasonably required for proper understanding and definition of the design and engineering of the project.

The contractor shall also provide soft copies of all drawings and documentation to be submitted. For the as-built documentation a well-organized electronic file including an Excel based table of contents, one (1) copy (plus electronic copy) shall be provided. All information with respect to connection points and interfaces between the Plant and the grid, and any other interface as well as for the entire PV Hybrid 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.

For project progress monitoring purpose, the contractor shall submit Gantt chart in PowerBI and shall update on a weekly basis to submit to the project. Any revision of the project implementation schedule shall not be delivered later than seven (7) days after such revision.

3.13.3 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 one (1) month after the date of contract award:

- Detail design reports of all systems, buildings, containers and structures.
- The contractor shall hand-in his method statements for construction methods
- General arrangement and detail layout drawings optimizing the available land.

- Project documents (data sheets, specifications, drawings) for major systems and components including system description of the main systems
- Single line diagrams
- Calculations and layouts for grounding, earthing, lightning protection, surge prevention
- Cable list and cable size calculation
- Geo technical study and land survey report
- Detailed layout drawings not limited to architectural, structural and electrical drawings.
- Report of the design loads and load bearing capacities buildings and structures
- Underground / aboveground ducts and cable arrangement drawings (civil and electrical)
- Quality assurance philosophy
- Information about corrosion protection for steel structures
- Operation and maintenance philosophy
- Emergency Response Plan
- HSE plan

3.13.4 Final Documentation

Before the final acceptance of the PV Hybrid plant the Contractor shall deliver to the Employer the final documentation, both in digital and hard copy. The final documentation for the PV plant shall be prepared in accordance with the IEC 62446 standard.

For the PV Hybrid plant the final documentation shall comprise at least the following:

- All As-built drawings (civil, mechanical, electrical) but not limited to:
  - SLD's
  - Cable routing plans and calculations
  - Cable list
  - Foundation and module mounting details
- Data sheets of installed components
- Warranties of installed components
- O&M manuals
- Site safety procedures
- HSE procedure and plan
- Test protocols
- Performed studies and tests
- Mechanical completion documents (not limited to):
  - Data sheets and manuals of components and equipment
  - Serial number of inverters, transformers, combiner boxes, etc.
  - Flash list of installed modules
  - Acceptance protocols
  - Calibration protocols
- Factory Acceptance Test Reports for all mechanical and electrical equipment
- Commissioning protocols
- Provisional Acceptance Certificate
- Punch lists (Reserve lists) for the Defects Liability Period
- Password for inverters, internal communication

Lastly the contractor must also submit Site services plan as required for the construction and commissioning of the PV plant such as electricity supply, potable water, instrument and service air, fuel supply, telecommunication etc.

3.14 Training Program

The contractor is required to provide training to engineers and technicians at each site as recommended by the Employers. Minimum 50 person days of training will be provided at all installation locations and at a central location as advised by the Employer. International training at contractor's workshops / office in country of origin will be provided.

The training shall comprise but not be limited to the following:

- Technical basics and components of a PV plant (PV modules and inverters) and grid storage
- General function of a PV plant, battery storage
- General function of a battery management system
- General function of power transformer sub-station, middle and low voltage switchgears
- General function of a hydropower generator controller
- Norms and standards
- Health, Safety, and Environmental (HSE), First Aid
- Control room daily work
- Operation of a PV plant and a hydropower plant
- Monitoring of the PV plant and the hydropower plant
- Access to the monitoring system
- Monitoring of the hybrid controller
- Fault detection
- Action plan after fault detection
- Preventive maintenance of all equipment and components
- Supervision and managing of corrective maintenance
- Performance of first level corrective maintenance, such as the replacement of spare parts and / or spare inverters
- Spare parts logistic and usage
- Plant documentation
- Monthly reporting
- Communication with suppliers
- Managing of insurance claims
- Maintenance of green areas, internal paths
- Cleaning of modules
- Maintenance and cleaning of pyranometers and other sensors

3.15 Spare parts, consumables and special tools

The contractor shall provide all spares parts and consumables necessary for the correct functioning during the warranty period and for performing the necessary maintenance activities. All spare parts shall be directly interchangeable with the corresponding parts in the power plants and shall meet the requirements of the present specifications.

All the special tools and other equipment that are necessary for the overhaul, maintenance and adjustment of the power plant facilities and equipment shall be included in the contractor's scope of supply.

Data Sheets for other minor items

LVDB (Low voltage Distribution Box)

				To be filled by Bidder	
Sl No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
1	**General data**				
1.01	Manufacturer				
1.01.1	Name				
1.01.2	country of assembling				
1.02	Applicable standards	IEC	IEC 60439		
1.03	Type test				
1.03.1	carried out		Yes / No		
1.03.2	date		dd-mm-yy		
1.03.3	testing laboratory				
1.03.3.1	name				
1.03.3.2	country				
2	**CONSTRUCTION DATA**				
A.	**Housing**				
2.01	Enclosure				
2.01.1	material		Braced rolled steel		
2.01.2	grade		G450		
2.01.3	applicable standards		BS -2989/729		
2.01.4	minimum thickness	mm	2		
2.02	Degree of protection		IP-55		
2.03	Ventilation		Yes		
2.03.1	applicable standards		BS5420		
2.04	Door fixings to fix the door panel during maintenance		Yes / no		
2.05	Corrosion protection details				
2.05.1	outside		Stove enameled textured paint RAL 7032		
2.05.2	inside		Gloss White		
2.06	Danger sign details				
2.06.1	material		stainless steel		
2.06.2	Grade		1.4301 (V2A)		
2.06.3	width	mm			
2.06.4	height	mm			
2.06.5	letters		sun light proof, no fading		
2.07	quality of paint				
2.07.1	height of letters	mm	100		
2.07.2	colors		red		
2.07.3	background				
2.07.4	letters	mm	100		
2.07.5	fixing bolts				
2.07.6	material		stainless steel		
2.07.7	grade		1.4301 (V2A)		
2.07.8	numbers	No.			
2.08	Identification sign details				
2.08.1	material		stainless steel		
2.08.2	grade		1.4301 (V2A)		
2.08.3	width	mm			
2.08.4	height	mm			
2.08.5	letters				
2.08.6	quality of paint		sun light proof, no fading		
2.08.7	height of letters	mm	100		
2.08.8	colors				
2.08.9	background				

				To be filled by Bidder	
Sl No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
2.08.10	letters		red		
2.09	fixing bolts				
2.09.1	material		stainless steel		
2.09.2	grade		1.4301 (V2A)		
2.09.3	numbers	No.			
B.	**Busbar**				
2.10	Applicable standards		IEC 60865-1		
2.11	Material				
2.11.1	Copper		Yes		
2.12	Dimensions				
2.12.1	height	mm			
2.12.2	width	mm			
2.13	Number of runs	No.			
2.14	Minimum clearances				
2.14.1	between phases	mm	25		
2.14.2	phases to earth	mm	20		
2.15	Phase barrier provided		yes/no		
2.16	Busbar insulation		EPOXY		
C.	**Neutral Bar**				
2.17	Applicable standards		IEC-60865-1		
2.18	Material		copper		
2.19	Dimensions				
2.19.1	height	mm			
2.19.2	width	mm			
2.20	Minimum clearances				
2.22.1	phases to neutral bus	mm	30		
2.22.2	Barrier to phases provided		yes/no		
2.23	Neutral bar insulation		EPOXY		
D.	**Earthing Bar**				
2.24	Applicable standards		60865-1		
2.25	Material		copper		
2.26	Dimensions				
2.26.1	height	mm			
2.26.2	width	mm			
E.	**Support Insulators**				
2.27	Manufacturer				
2.27.1	name				
2.27.2	country of manufacturer				
2.28	Applicable standards		IEC		
2.29	Type				
2.30	Material				
F.	**Air Break Circuit Breaker (Incomers & Bus Sectionaliser)**				
2.31	Manufacturer				
2.31.1	name				
2.31.2	country of manufacturing				
2.32	Applicable standards		IEC-60265		
2.33	No. of poles				
2.34	Arc-quenching medium		air		
2.35	Operating facilities				
2.35.1	hand		yes		
2.35.2	motor (provision)		yes		
2.35.3	remote control (provision)		yes		
2.35.4	counter		yes		
2.36	Mechanical position indicator of main contact		yes		
2.37	Operation mechanism				
2.37.1	opening		spring		
2.37.2	closing		spring		

				To be filled by Bidder	
Sl No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
G.	**CT for metering**		**yes / no**		
H.	**MCCB (Outgoing),**				
2.38	Manufacturer				
2.38.1	name				
2.38.2	country of manufacturing				
2.39	Type		molded case		
2.40	Applicable standards		IEC-60947-2 / BS3871		
2.41	Number of MCCB poles				
2.42	Protection				
2.42.1	thermal		yes		
2.42.2	magnetic		yes		
I.	**MCB**				
2.43	Number of poles				
J.	**Space Heater**				
2.44	Manufacturer				
2.44.1	name				
2.44.2	country of manufacturing				
2.45	Applicable standards		IEC		
2.46	Control system				
2.46.1	humidistat		PTC type		
2.46.2	thermostat		PTC type		
2.47	MCB for heater provided		yes		
3	**ELECTRICAL DATA**				
A.	**Common**				
3.01	Rated voltage	V	440		
3.02	Nominal operating voltage	V	400		
3.03	Frequency	H_z	50		
3.04	Power frequency withstand test voltage, 1s	kV_{rms}	2		
3.04.1	Rated short-circuit current, 1s	kA	25		
3.04.2	Rated short-circuit current, 1s	kA	100		
3.05	Control supply voltage				
3.05.1	trip and closing coils	V	240		
3.05.2	spring charging motors	V	240		
B.	**Busbars**				
3.06	Bus Bar Rating	A			
3.07	Busbar short circuit Rating	A			
3.08	Type of Insulation for Busbar Mounting				
C.	**Busbar Support Insulators**				
3.09	Visible corona discharge voltage				
3.10	Creepage distance	mm			
D.	**Air Break Circuit Breaker (Incomers & Bus Sectionaliser)**				
3.11	Rated current carrying capacity at max. 40°C	A			
3.12	Operating current carrying capacity at max. 50°C				
3.13	Rated symmetrical breaking current	kA			
3.14	Rated making current	kA			
3.15	Temperature rise of main contacts when carrying continuous current	°C			
3.16	Thickness of silver coating for main contact	micron			
3.17	Number of operations circuit breaker can make without inspection replacement of contacts or other parts at 100% rated breaking current	No.	min. 20000		
3.18	Auxiliary contacts				
3.18.1	number	No.			
3.18.2	rating	A			
3.19	Total operating time	msec			
3.19.1	Trip free type	yes			
3.19.2	Operating mechanism				
3.20	motor rating				

				To be filled by Bidder	
Sl No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
3.21.1	voltage	V	240		
3.21.2	current	A			
3.21.3	power	W			
3.22	time for fully charging the closing spring	sec			
3.22.1	emergency manual charging facility provided?	yes			
3.22.2	limits of voltage for satisfactory operation of following devices, as percentage of normal Voltage				
3.22.3	motor	%	85 to 110		
3.22.4	closing coil	%	85 to 110		
3.22.5	tripping coil	%	70 to 110		
E.	**MCCB (Outgoing),**				
3.38	Rated current carrying at max. 40 degC				
3.38.1	single-phase	A			
3.38.2	three-phase	A			
3.39	Operating current carrying at max. 50 degC				
3.39.1	single-phase	A			
3.39.2	three-phase	A			
3.40	Overload and short circuit release		yes		
3.41	Rated short-circuit current, 1s	kA			
3.42	Rated breaking current	kA			
3.43	Rated making current	kA			
3.44	Rated short-circuit current, 1s	kA			
3.45	MCCB characteristics coordinated with down-stream circuit protection		yes		
F.	**Space Heater**				
3.46	Power	W			
3.47	Rated voltage	V_{ac}	230		
3.48	Rated current	A			
3.49	MCCB				
3.49.1	rated current	A			
G.	**Socket**				
3.50	Rated voltage	V_{ac}	230		
3.51	Rated current	A			
3.52	MCCB				
3.52.1	rated current	A			
H.	**Lamp**				
3.53	Power	W	100		
3.54	Rated voltage	V_{ac}	230		
3.55	Rated current	A			
3.56	Fuse				
3.56.1	rated current	A			

Data Sheet for Distribution Boxes				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
1	**General data**				
1.1	Name of Manufacture				
1.2	Country of Manufacture				
1.3	Address of Manufacturer				
1.4	Applicable standards		IEC 61439		
2	**Construction Data**				
2.1	**Enclosure**				
2.1.1	Material		Outdoor weatherproof GRP sealed		
2.1.2	Thickness		3mm		
2.1.3	Colour		RAL 7032		

Data Sheet for Distribution Boxes				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
2.2	Dimension (Height / Width / Depth)	mm	As per project requirements		
2.3	Weight	kg			
2.4	Degree of protection	IP	67		
2.5	Front cover material				
2.6	Back cover material				
2.7	Frame material (if applicable)				
2.8	Locks-Material & Grade				
2.9	Lifting devices				
3	**Electrical data**				
3.1	Rated voltage	V	440		
3.2	Nominal operating voltage	V	400		
3.3	Frequency	Hz	50		
3.4	Power frequency withstand test voltage	kVrms	2.5		
3.5	Busbar Rating	Amps	100		
3.6	Rated Short Circuit Rating, 1s	kA	46		
3.7	Type of Insulation on Busbars				
3.8	Type of Terminal Blocks				
3.9	Rating of Terminal Blocks				
3.10	Earthing arrangement				
4	**Supporting Documents**				
4.1	All the drawings enclosed		Yes		
4.2	All type test reports enclosed		Yes		
4.3	Adequacy of busbar size for specified current rating		Yes		

Data Sheet for Armoured Underground cables

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
1	**General data**				
1.1	Name of Manufacture				
1.2	Country of Manufacture				
1.3	Address of Manufacturer				
2	**Construction Data**				
2.1	**Conductor/Neutral**				
2.1.1	Applicable standards		IEC 60228, BS 6360		
2.1.2	Conductor Material		Annealed Copper wires		
2.1.3	Nominal cross-section of each conductor	mm2			
2.1.4	Neutral Material		Annealed Copper wires		
2.1.5	Nominal cross-section of each Neutral	mm2			
2.1.6	Number of Cores				
2.2	**Conductor/Neutral Insulation**				
2.2.1	Applicable standards		BS 5467, BS 7655		
2.2.2	Material		XLPE		
2.2.3	Nominal thickness of insulation	mm			
2.2.4	Minimum average insulation thickness	mm			
2.2.5	Colours		R=Red, S=Yellow, T=Blue, N=Black		

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
2.2.6	UV-resistant		Yes		
2.3	**Binder/separation**				
2.3.1	Material		Polypropylene		
2.3.2	Approximate diameter	mm			
2.4	**Inner sheath (bedding)**				
2.4.1	Applicable standards		BS 5467		
2.4.2	Material		PVC-ST2		
2.4.3	Nominal thickness	mm			
2.4.4	Colour				
2.4.5	Approximate diameter	mm			
2.5	**Armour**				
2.5.1	Applicable standards		BS 5467, BS EN 10257-1		
2.5.2	Material		Galvanised steel wires		
2.5.3	Number of wires	Nos.			
2.5.4	Nominal diameter of wires	mm			
2.5.5	Shape		Round		
2.5.6	Cross-section of armour	mm2			
2.5.7	Tensile strength	N/mm2			
2.5.8	Min. elongation after break	%			
2.5.9	Approximate diameter	mm			
2.6	**Outer sheath**				
2.6.1	Applicable standards		BS 5467, BS 7655		
2.6.2	Material		PVC-ST2		
2.6.3	Nominal thickness	mm			
2.6.4	Minimum thickness	mm			
2.6.5	Resistant to sulphide		Yes		
2.6.6	Chloride paraffin free		Yes		
2.6.7	Fire retardant		Yes		
2.6.8	Length marking at every meter interval		Yes		
2.6.9	Text embossed as specified		Yes		
2.6.10	Colour		Black		
2.6.11	Approx. overall diameter of cable	mm			
2.7	**Weights**				
2.7.1	Complete cable	kg/m			
2.7.2	Copper	kg/m			
2.7.3	Steel	Kg/m			
3	**Electrical data**				
3.1	Rated voltage (Uo/U)	kV	0.6/1		
3.2	Highest system voltage (Umax)	kV	1.2		
3.3	Frequency	Hz	50		
3.4	Power frequency withstand voltage (4 x Uo)	kV/4hrs	2.4		
3.5	**Maximum current carrying capacity**				
3.5.1	In ground: soil temperature=40°C, depth=75cm, T.R.=1.5mK/W				
3.5.1.1	1 cable	Amp			
3.5.1.2	2 cables (d=30cm)	Amp			

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
3.5.1.3	3 cables (d=30cm)	Amp			
3.5.2	**in concrete cable trench/cable room: air=50°C**				
3.5.2.1	1 cable trays/racks	Amp			
3.5.2.2	2 to 3 cables trays/racks	Amp			
3.5.2.3	4 to 5 cables trays/racks	Amp			
3.6	**Minimum short circuit current of the conductor**				
3.6.1	For 1.0 s duration	kA			
3.6.2	For 0.5 s duration	kA			
3.7	**Minimum short circuit current of armouring**				
3.7.1	For 1.0 s duration	kA			
3.8	Maximum permissible continuous conductor temperature	°C	90		
3.9	Maximum permissible continuous temperature of cable surface	°C			
3.10	Maximum permissible conductor temperature for 117% of max. transmission capacity, prevailing maximum 100 hrs/year and 500 hrs in total (emergency overload)	°C	105		
3.11	Maximum permissible short-circuit temperature for welded/pressed conductor connections	°C	250		
3.12	Appropriate duration	s			
3.13	Maximum DC conductor resistance at 20°C	Ω/km			
3.14	Maximum AC conductor resistance at 90°C and for cable arrangements as per above	Ω/km			
3.15	Insulation resistance at 20°C	μΩ/km			
3.16	Capacitive reactance	μF/km			
3.17	Inductive reactance	Ω/km			
3.18	Resistance of cable armour at 20°C	Ω/km			
4	**Other Data**				
4.1	**Minimum permissible bending radius D**				
4.1.1	In ducts	m			
4.1.2	Laid direct or in air	m			
4.1.3	Adjacent to joints or terminals	m			
4.1.4	Maximum permissible pulling force	kN			
4.1.5	Maximum permissible sidewall pressure to cable at bending point	kN/m			
5	**Supporting Documents**				
5.1	All the drawings enclosed		Yes		
5.2	All type test reports enclosed		Yes		
5.3	Technical literature enclosed		Yes		

Data Sheet for MCCB (moulded case circuit breaker)

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
1	**General data**				
1.1	Name of Manufacture				
1.2	Country of Manufacture				
1.3	Address of Manufacturer				

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
2	**Construction Data**				
2.1	**Conductor/Neutral**				
2.1.1	Applicable standards		IEC 60228, BS 6360		
2.1.2	Conductor Material		Annealed Copper wires		
2.1.3	Nominal cross-section of each conductor	mm2			
2.1.4	Neutral Material		Annealed Copper wires		
2.1.5	Nominal cross-section of each Neutral	mm2			
2.1.6	Number of Cores				
2.2	**Conductor/Neutral Insulation**				
2.2.1	Applicable standards		BS 5467, BS 7655		
2.2.2	Material		XLPE		
2.2.3	Nominal thickness of insulation	mm			
2.2.4	Minimum average insulation thickness	mm			
2.2.5	Colours		R=Red, S=Yellow, T=Blue, N=Black		
2.2.6	UV-resistant		Yes		
2.3	**Binder/separation**				
2.3.1	Material		Polypropylene		
2.3.2	Approximate diameter	mm			
2.4	**Inner sheath (bedding)**				
2.4.1	Applicable standards		BS 5467		
2.4.2	Material		PVC-ST2		
2.4.3	Nominal thickness	mm			
2.4.4	Colour				
2.4.5	Approximate diameter	mm			
2.5	**Armour**				
2.5.1	Applicable standards		BS 5467, BS EN 10257-1		
2.5.2	Material		Galvanised steel wires		
2.5.3	Number of wires	Nos.			
2.5.4	Nominal diameter of wires	mm			
2.5.5	Shape		Round		
2.5.6	Cross-section of armour	mm2			
2.5.7	Tensile strength	N/mm2			
2.5.8	Min. elongation after break	%			
2.5.9	Approximate diameter	mm			
2.6	**Outer sheath**				
2.6.1	Applicable standards		BS 5467, BS 7655		
2.6.2	Material		PVC-ST2		
2.6.3	Nominal thickness	mm			
2.6.4	Minimum thickness	mm			
2.6.5	Resistant to sulphide		Yes		
2.6.6	Chloride paraffin free		Yes		
2.6.7	Fire retardant		Yes		
2.6.8	Length marking at every meter interval		Yes		
2.6.9	Text embossed as specified		Yes		
2.6.10	Colour		Black		

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
2.6.11	Approx. overall diameter of cable	mm			
2.7	**Weights**				
2.7.1	Complete cable	kg/m			
2.7.2	Copper	kg/m			
2.7.3	Steel	kg/m			
3	**Electrical data**				
3.1	Rated voltage (Uo/U)	kV	0.6/1		
3.2	Highest system voltage (Umax)	kV	1.2		
3.3	Frequency	Hz	50		
3.4	Power frequency withstand voltage (4 x Uo)	kV/4hrs	2.4		
3.5	**Maximum current carrying capacity**				
3.5.1	In ground: soil temperature=40°C, depth=75cm, T.R.=1.5mK/W				
3.5.1.1	1 cable	Amp			
3.5.1.2	2 cables (d=30cm)	Amp			
3.5.1.3	3 cables (d=30cm)	Amp			
3.5.2	**in concrete cable trench/cable room: air=50°C**				
3.5.2.1	1 cable trays/racks	Amp			
3.5.2.2	2 to 3 cables trays/racks	Amp			
3.5.2.3	4 to 5 cables trays/racks	Amp			
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4	**Other Data**				
4.1	**Minimum permissible bending radius D**				
4.1.1	In ducts	m			
4.1.2	Laid direct or in air	m			
4.1.3	Adjacent to joints or terminals	m			
4.1.4	Maximum permissible pulling force	kN			
4.1.5	Maximum permissible sidewall pressure to cable at	kN/m			

				To be filled by Bidder	
No.	**Description**	**Unit**	**Requirements**	**Data**	**Note**
	bending point				
5	**Supporting Documents**				
5.1	All the drawings enclosed		Yes		
5.2	All type test reports enclosed		Yes		
5.3	Technical literature enclosed		Yes		

4 Drawings

The following drawings are provided in the attachment.

These are indicative only. The detail drawings considering site specific details, equipment, short circuit rating, busbar sizes, HT protection, LT/HT metering, cable sizes etc. shall be prepared by the contractor. Further, other drawings including and not limited to- DC cable layout, AC cable lay-out, LA and earthing layout, Civil drawings (Main Control Room, Trenches, Drains, Plumbing, Container Base frame) shall be prepared by the contractor.

Sl. No.	Drawing Number	Title
01	Conceptual drawing of PV array mounting structure and foundation	MOUNTING STRUCTURE & FOUNDATION
02	String design layout	STRING DESIGN
03	Transformer	Transformer
04	Single line diagram for Gamgadi	SLD_ Mugu
05	Single line diagram for Jumla	SLD _Jumla
06	Single line diagram for Dolpa	SLD _Dolpa
07	Single line diagram for Humla	SLD _Humla

ANNEXURE- I

LIST OF PREFERRED (SHORTLISTED) MAKE

It is preferred that the following equipment be supplied from the manufacturers listed here-under:

(i) VCB/ACB: ABB, AREVA/ALSTOM, Siemens, Mitsubishi, GE or equivalent.
(ii) Cable Jointing Kit: Densons, Prysmian, ENSTO, Raychem, 3M
(iii) XLPE Cables: KEI India, LS cable and system, Dynamic cables or equivalent

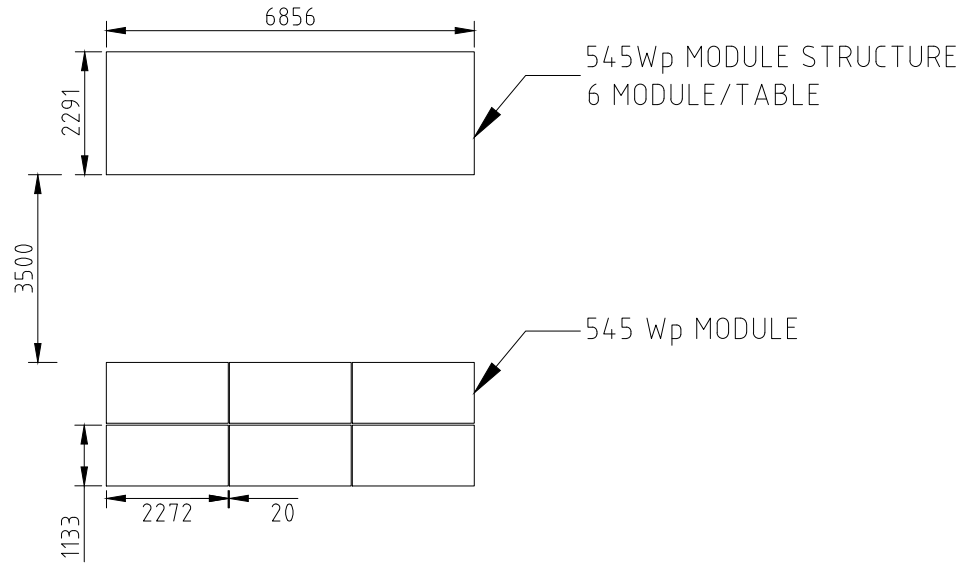
The bidders may offer equipment/brands other than those listed above that are better or equivalent with regard to quality and performance substantiated with appropriate documents. The bidder is required to submit all technical information, brochures, test reports of the proposed equipment for assessing equivalence with the shortlisted vendor during the bid submission.

ANNEXURE II - Environment and Social Impact and Mitigation Plan

Project Component/Activity	Impact or Risk to be mitigated	Mitigation Measures	Performance Indicator
Pre-Construction			
Survey	Natural Hazards	Ensure equipment to be operational on maximum gusts of wind, optimized to operate during annual weather extremities, slope stability	No Breaches of national regulation and/or international good practice guidelines
	Safety	Ensure Placement of equipment in compliance to national safety standards and no/minimal interference with public utilities	
	Topography	Ensure levelling works to have minimal impacts on movement on public roads	
Construction			
Upgrading of Access Road	Transportation of goods to the site, Cutting of Corners, Levelling, Filling and Rolling Works causing air pollution, disruption of other utility services	Consultation with the property owners along the access roads Sprinkling of Water along the road Timely restoration of any disruption of other utility services Works to be carried out avoiding damages to structures as buildings and any damages to be timely compensated Proper usage of Personal Protective Equipment (PPE) Visible Warning Signage in Local Language to be placed	Meet National Regulation and comply with ADB SPS requirements
Levelling of Land	Air Pollution from land levelling works, removal of vegetation, soil erosion and dusty condition	Excess materials to be used as fill material, any disposal site of such material will need to be restored and no drainages shall be blocked. Tree plantation around the boundary, as possible, ensuring the vegetation without blocking the sunlight to solar panels	Contractor to Follow EHS Guidelines and Implement Construction Environment Management Plan
Workers Camp	Health and Safety Risks	Construction camps shall include proper sanitation, alternative fuel to firewood, clean eating area, water supply, and waste disposal facilities, including primary treatment for domestic sewage (pit latrines prohibited, adequate number of toilets with hot and cold running water to be connected to existing sewerage system, septic tank, or self-contained units for disposal of wastewater off site to sewage treatment works) and secure storage of domestic solid wastes for disposal of site to suitably licensed landfill site. Sufficient toilet facilities pit toilets or septic/absorption system should be provided for the number of workers,	Contractors and construction workers are fully aware of their responsibilities under EMP. Photos and records submission through regular monitoring reports

		and there should be an indication of whether the toilet facility is "in use" or "vacant" if not segregated. Any health and safety incidents (near miss, minor, lost time, fatal) involving workers or community to be reported to PMD within 24 hours of occurrence with a response plan detailing the incident and how its reoccurrence will be avoided, PMD to report any lost time or fatal incidents to ADB within 48 hours. Adequate Labor Cabin Size to be maintained	
Storage Yards	Site Selection and Heavy Machinery usage. Air and Noise Pollution	Select location of storage areas away from environmentally sensitive areas Timely maintenance of vehicle to be within national emission standards, limit idling of vehicle, prohibit unnecessary noise of engines by using silencer	Mitigation measures to be successfully implemented by contractor as determined through regular site inspection, photographic records etc.
Use of Local Water Supply	Over Burdening the Local Water Supply Systems	Adequate approvals for use of water supply systems without causing impacts on local users	Compliance with national regulation, no outstanding grievances and reporting of regular monitoring reports
Construction Office and Quarters	Air and Water Pollution and Generation of Wastes	Preferably, readymade pre-fabricated structure shall be used for establishing camp. Kitchen and dining area shall be away in separate shed. Safe disposal of wastes.	Compliance with national regulation, no outstanding grievances and reporting of regular monitoring reports
Foundation of Solar Panels	Air Pollution from drilling operation and concrete mixing	Water Sprinkling to reduce air pollution Placement of concrete mixing plant away from water sources and placement of sacks or tarpaulin to prevent pollution of land	Mitigation measures successfully implemented by contractor as determined through regular site inspection, photographic records etc. No outstanding grievances
Erection of posts and drilling	Air Pollution from Loose Dust, Blockages of natural drainage and noise pollution	Minimize air pollution by water sprinkling and reduce noise generating drilling works during morning and evenings Recyclable wastes to be stored for offsite disposal	Mitigation measures successfully implemented by contractor as determined through regular site in-

			spection, photographic records etc. No outstanding grievances
Installation of Inverters, cabling and lightning arresters	Short-circuit and fires	Proper sizing of equipment, trained personnel to handle interconnections and placement of fire extinguishers	Mitigation measures successfully implemented by contractor as determined through regular site inspection, photographic records etc. No outstanding grievances
Construction of Power Evacuation Line to Pooling Station	Shadows on panels and electrical safety	Trained personnel to route the line away from the panels in compliance to national electricity safety rules	To follow national regulation, SPS requirements and international best practices
Construction of Store, Toilets and Control Room	Air Pollution from Loose Dust, Noise Pollution	Work to be carried out between sunrise to sunset.	To follow national regulation, SPS requirements and international best practices. Regular Site Inspection and periodic monitoring report
Used Battery Storage and Disposal	Hazardous Waste leach heavy metals such as lead and cadmium (from solar panels) contaminate ground water and have detrimental effects on health. Lead is known to have impacts on brain development and cadmium as a carcinogen.	Undertaking from the contractor to dispose hazardous wastes to approved recyclers or return to the manufacturer, ensuring fully trained personnel handle interconnections and chemicals. Equipment selection needs to prioritize purchase from manufacturers who have included costs for disposal, transportation from the site and recycling of used and damaged batteries.	To follow national regulation and SPS. Regular Site inspection, periodic monitoring requirements and actions plan.



NOTES:

1. ALL EQUIPMENT TO BE INSTALLED AS PER ALL RELEVANT MANUFACTURER REQUIREMENTS.
2. INSTALLATION OF SOLAR MODULES AND MOUNTING FRAMES TO BE LABELED IN ACCORDANCE WITH RELEVANT SERVICE AND INSTALLATION RULES.
3. ALL EXPOSED CONDUCTIVE METAL COMPONENTS MUST BE EQUIPOTENTIALLY BONDED AND CONNECTED TO MAIN EARTH.
4. EARTH LUGS TO BE COMPOSED OF TINNED COPPER.
5. ALL BOLTS, NUTS, AND WASHERS SHALL BE COMPOSED OF STAINLESS STEEL.
6. DRAWING COLOR CODED. PRINT COPIES IN COLOR.
7. ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE STATED.

DESIGN PANEL	
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NOT FOR CONSTRUCTION

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ADB_NEA PV+BESS PROJECT

CONCEPTUAL DRAWING OF PV ARRAY MOUNTING STRUCTURE & FOUNDATION

A4	TOTAL SHEETS:
SHEET SIZE	PROJECT No:

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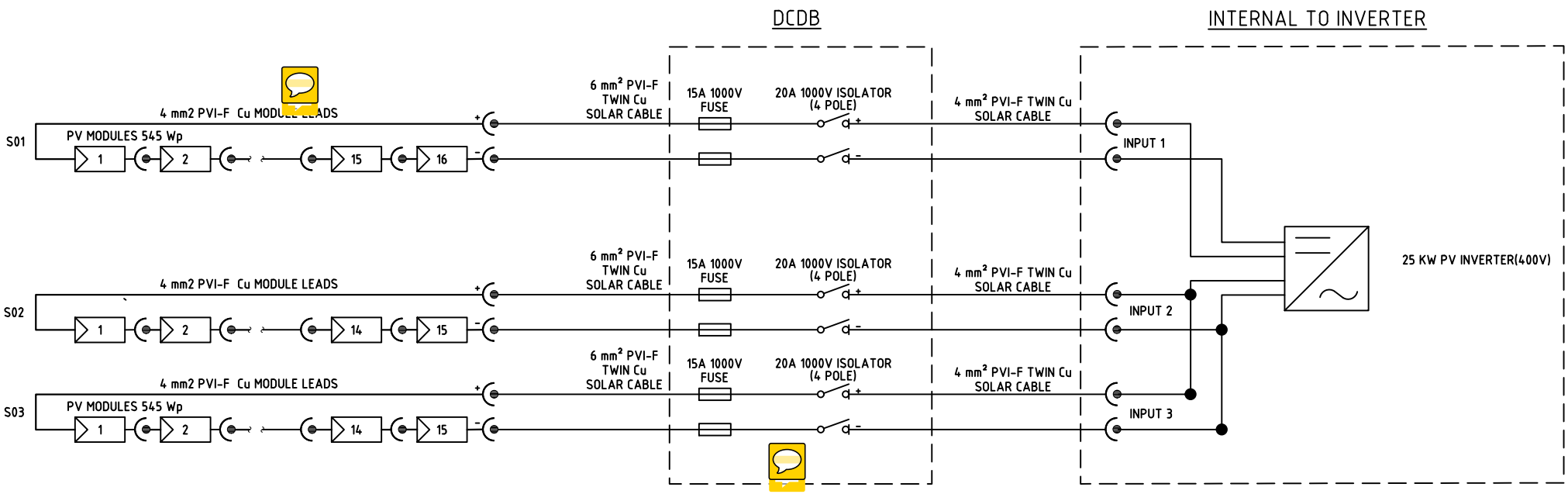

PV ARRAY

NO. OF MODULES:	46
MODULE RATING:	545 W
SHORT CIRCUIT CURRENT:	13.90 A
PV MODULE MAX. VOLTAGE (AT -33 DEGREES C):	57.54 V
PV MODULE MIN. VOLTAGE (AT 23 DEGREES C):	38.53 V

LEGEND:

- FAULT MAKE LOAD BREAK DISCONNECTOR
- DISCONNECTOR (NON-LOAD BREAK)
- FUSE
- PV MODULE
- MODULE CONNECTOR
- ELECTRICAL JUNCTION
- INVERTER

NOTES:

1. DOUBLE INSULATED CABLES INSTALLED IN UV RESISTANT CABLE TRAY/CONDUIT SHALL BE USED IN ARRAY AREA.
2. PV MODULES TO BE INSTALLED AS PER MANUFACTURER'S INSTALLATION MANUAL.
3. TERMINATION OF DC CABLES SHALL BE PERFORMED IN COMPLIANCE WITH ALL MANUFACTURER'S REQUIREMENTS FOR BOTH INVERTERS AND DC ISOLATORS.
4. DC CONNECTORS WITH SEALING PLUGS TO BE CONNECTED TO THE DC INPUTS OF THE INVERTER AS PER INVERTER OPERATING MANUAL.

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String Design Layout

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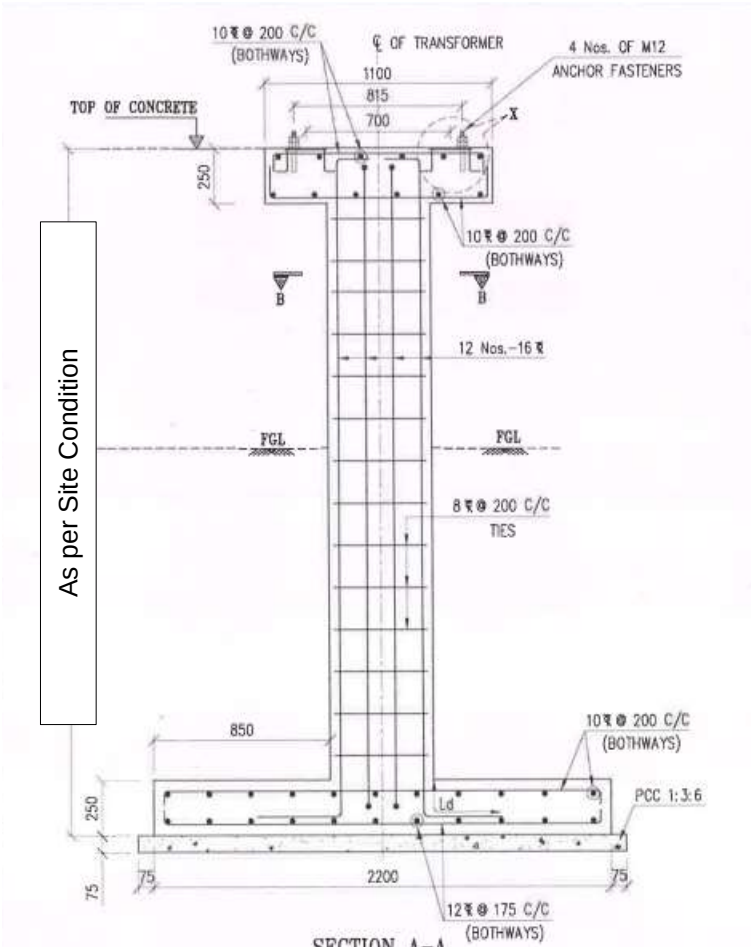
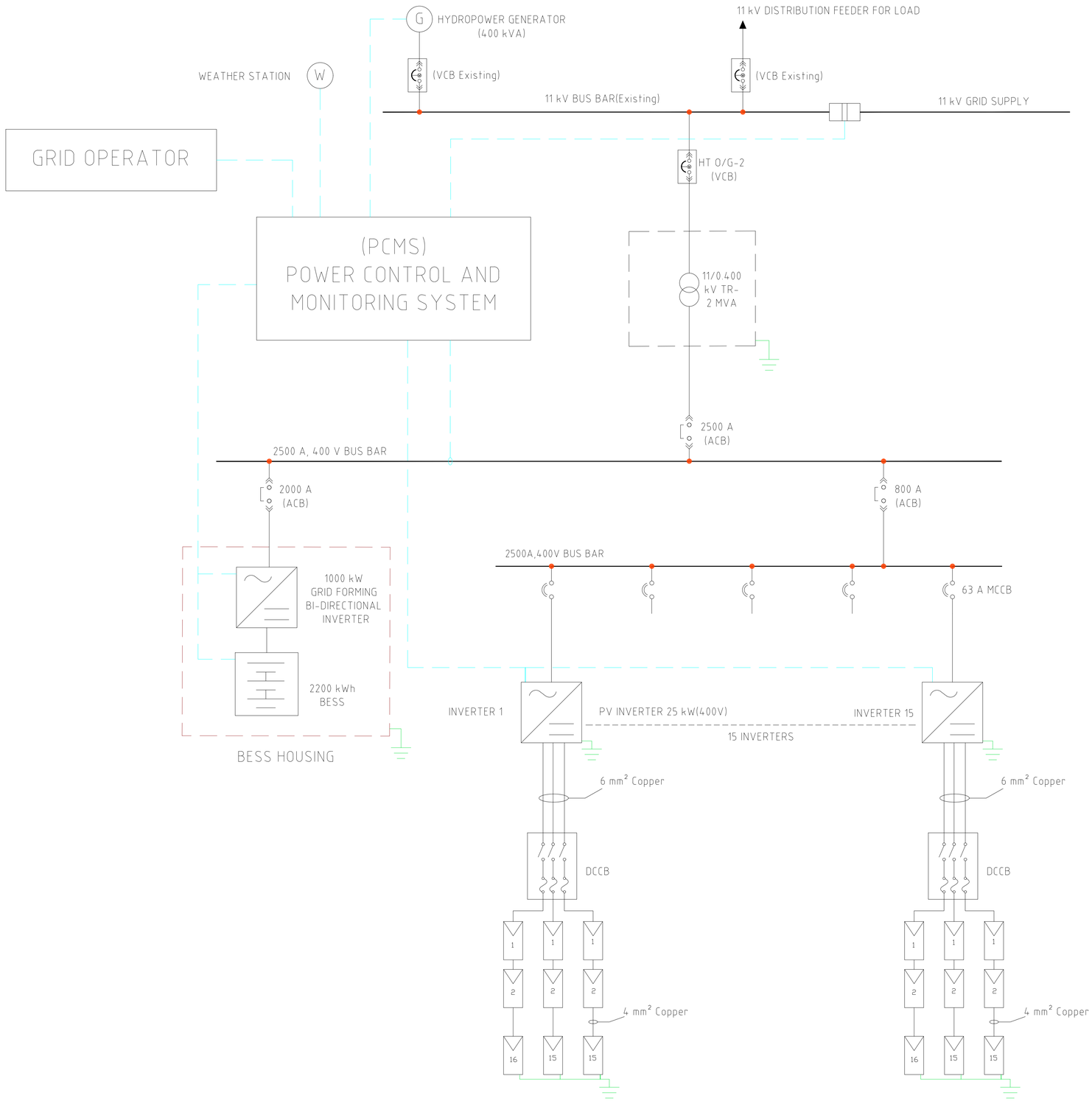

10ϕ @ 200 C/C
(BOTHWAYS)
℄ OF TRANSFORMER
4 Nos. OF M12
ANCHOR FASTENERS
1100
815
700
X
TOP OF CONCRETE
250
10ϕ @ 200 C/C
(BOTHWAYS)
B
B
12 Nos.-16ϕ
FGL
FGL
8ϕ @ 200 C/C
TIES
As per Site Condition
850
10ϕ @ 200 C/C
(BOTHWAYS)
250
Ld
PCC 1:3:6
75
75
2200
75
12ϕ @ 175 C/C
(BOTHWAYS)



LEGENDS	
	AIR CIRCUIT BREAKER (ACB)
	VACUUM CIRCUIT BREAKER (VCB)
	MOULDED CASE CIRCUIT BREAKER (MCCB)
	GENERATOR
	TRANSFORMER
	CONTROL CIRCUIT
	ELECTRICAL JUNCTION
	EARTH POTENTIAL
	INVERTER
	BATTERY ENERGY STORAGE SYSTEM(BESS)
	BUS COUPLER
	PV Module(545Wp)
W	WEATHER STATION

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ADB_NEA PV+BESS PROJECT
SINGLE LINE DIAGRAM
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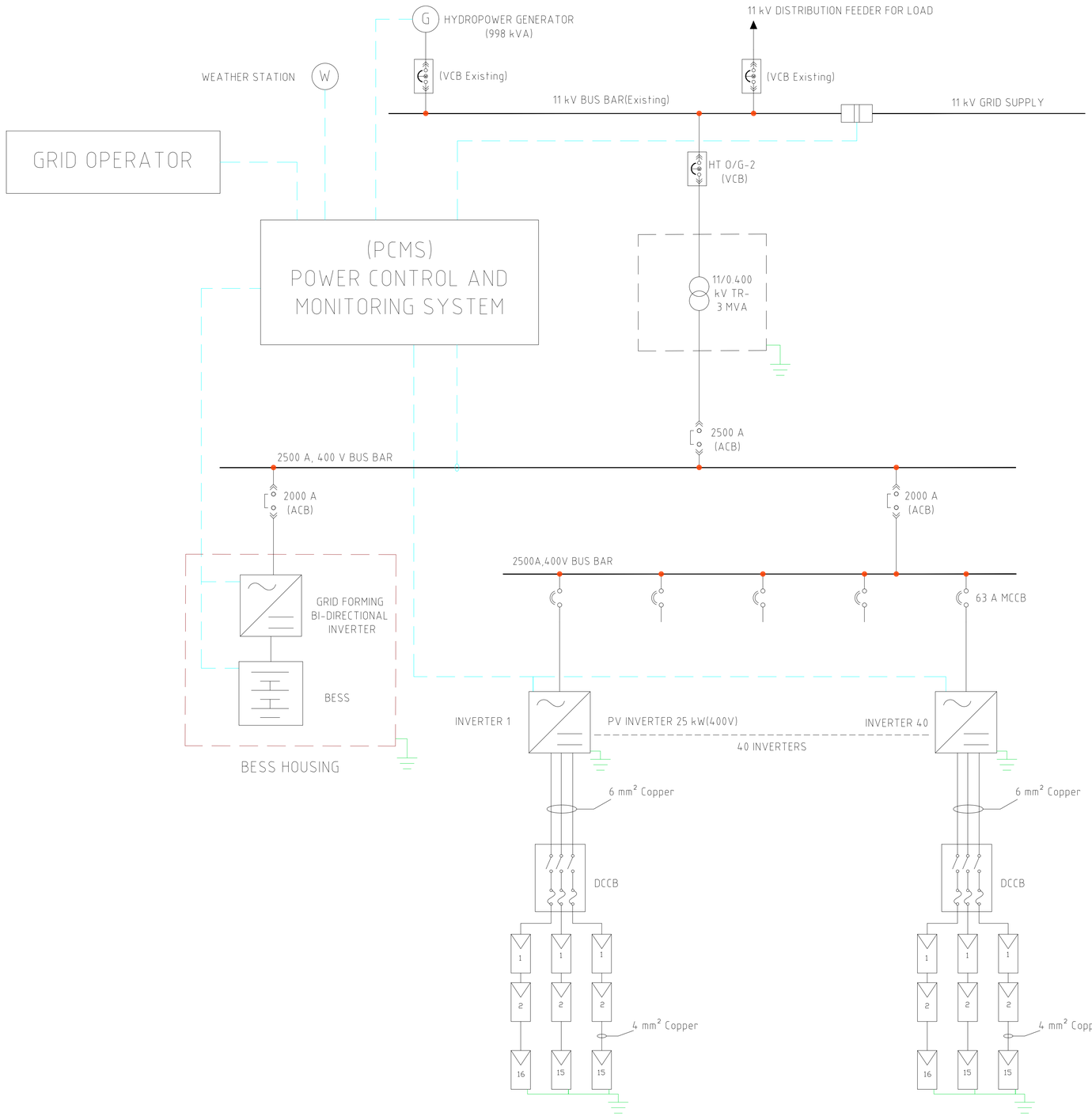

LEGENDS	
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	VACUUM CIRCUIT BREAKER (VCB)
	MOULDED CASE CIRCUIT BREAKER (MCCB)
	GENERATOR
	TRANSFORMER
	CONTROL CIRCUIT
	ELECTRICAL JUNCTION
	EARTH POTENTIAL
	INVERTER
	BATTERY ENERGY STORAGE SYSTEM(BESS)
	BUS COUPLER
	PV Module(545Wp)
W	WEATHER STATION

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SINGLE LINE DIAGRAM
JUMLA HYDRO

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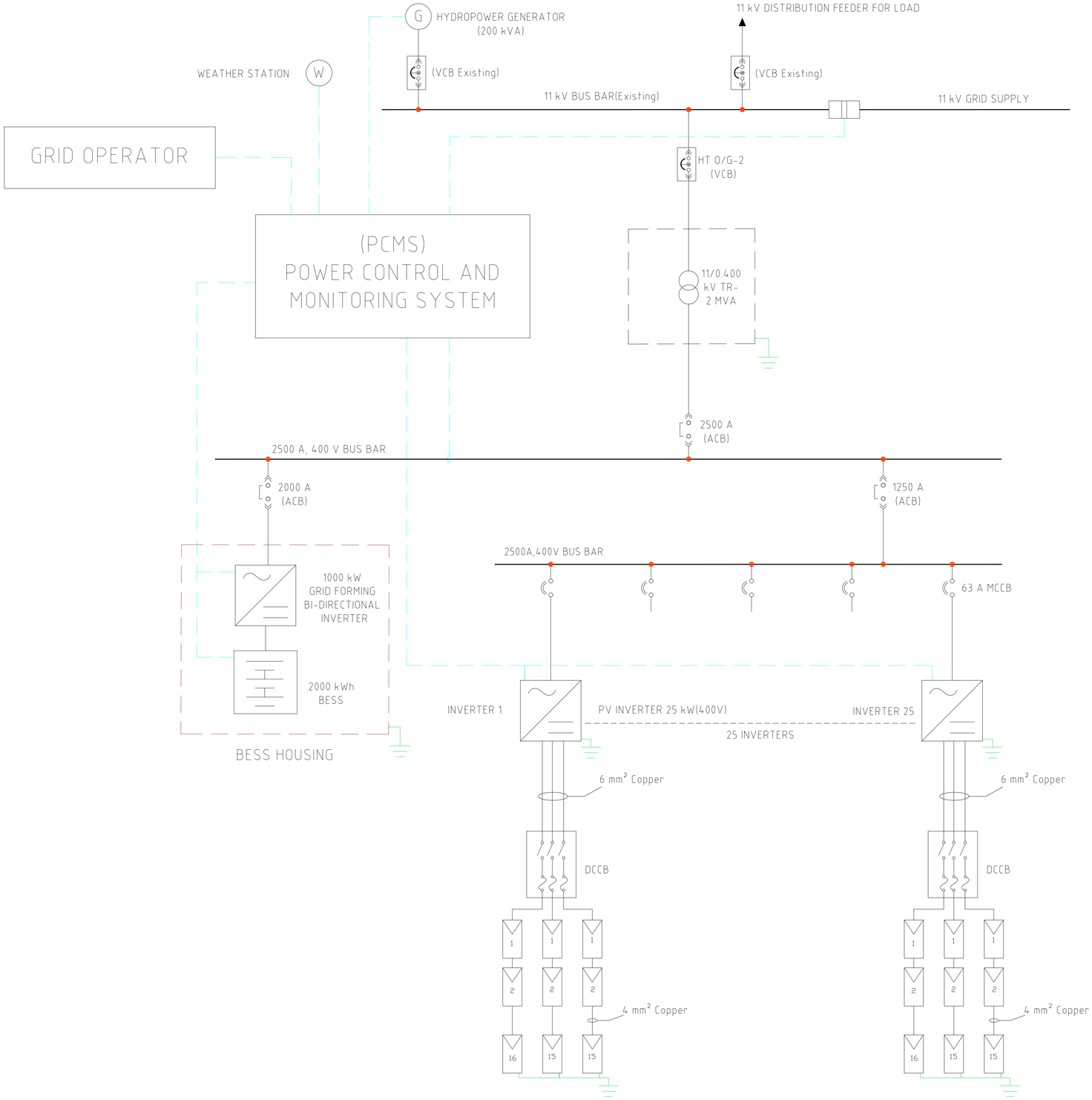

LEGENDS	
	AIR CIRCUIT BREAKER (ACB)
	VACUUM CIRCUIT BREAKER (VCB)
	MOULDED CASE CIRCUIT BREAKER (MCCB)
	GENERATOR
	TRANSFORMER
	CONTROL CIRCUIT
	ELECTRICAL JUNCTION
	EARTH POTENTIAL
	INVERTER
	BATTERY ENERGY STORAGE SYSTEM(BESS)
	BUS COUPLER
	PV Module(545Wp)
W	WEATHER STATION

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ADB_NEA PV+BESS PROJECT
SINGLE LINE DIAGRAM
DOLPA

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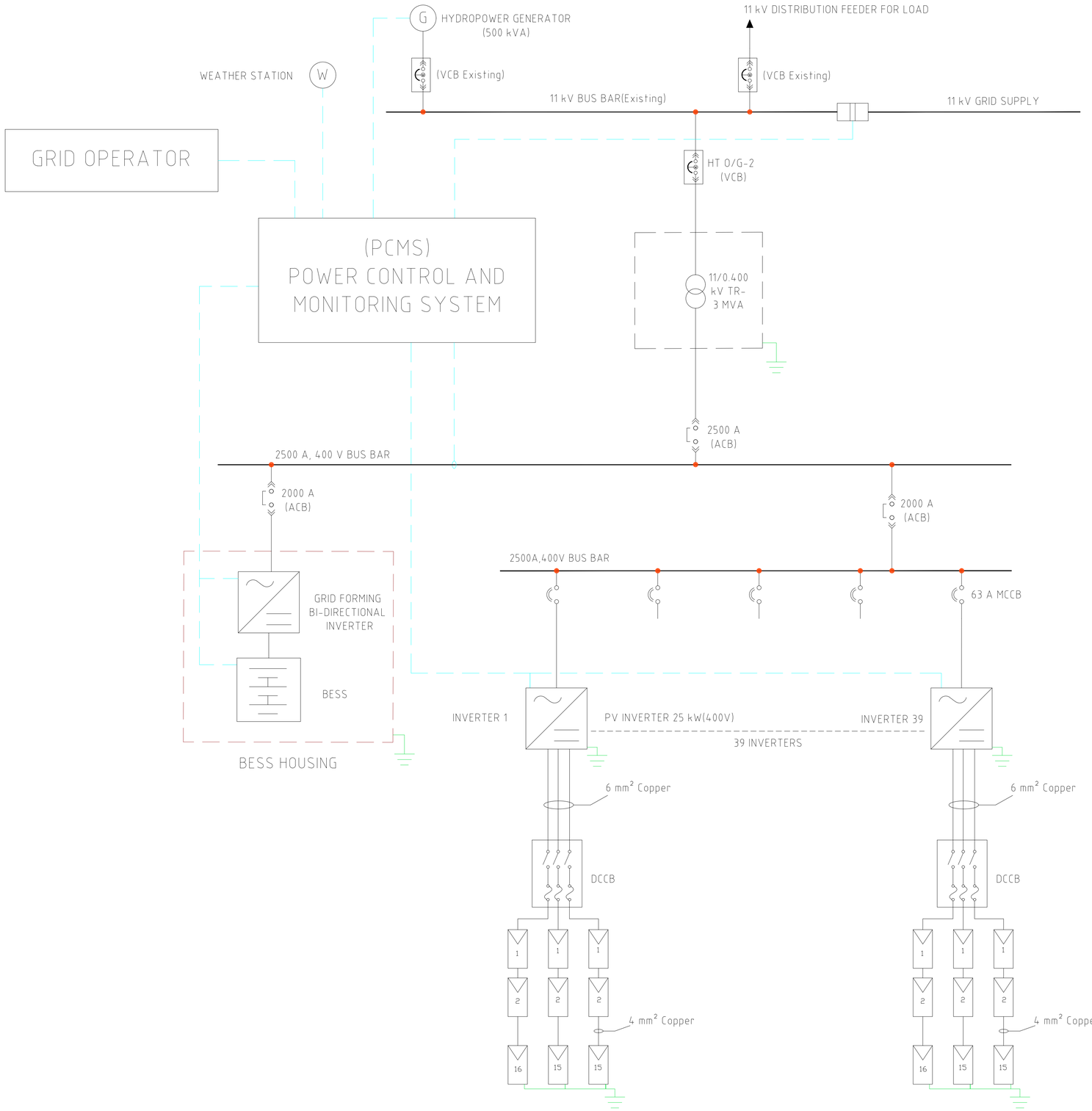

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	GENERATOR
	TRANSFORMER
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	BUS COUPLER
	PV Module(545Wp)
W	WEATHER STATION

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SINGLE LINE DIAGRAM
HUMLA

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