NATIONAL POWER CORPORATION

SUPPLEMENTAL / BID BULLETIN NO. 1
to the Bid Documents for the:

DESIGN, SUPPLY, DELIVERY, INSTALLATION, TESTING AND COMMISSIONING OF CALUTCOT ISLAND SOLAR PV-DIESEL HYBRID SYSTEM (WITH ESS) UNDER PR NO. HO-PIB24-011/ REF. NO. PB240312-NA00076

29 FEBRUARY 2024

All prospective bidders and authorized copy holders of the Bid Documents of the abovementioned project are hereby advised of the changes in the provisions of the bid documents, to wit:

A. **Replacement** of Section VI, Part I – Technical Specifications, Electrical Works, see attached revised copy comprising of **68** pages.

B. **Replacement** of Section VI, Part II – Technical Data Sheets, Electrical Works, see attached revised copy comprising of **42** pages.

C. **Contact Person: Engr. Marx Sean de la Cruz**
Contact Number: 0906-476-4283

All prospective bidders and authorized copy holders of the Bid Documents are hereby notified on the upcoming Bid Submission/Opening scheduled on 12 March 2024, 9:30 A.M. at Kañao Function Room, NPC Bldg. Diliman, Quezon City.

All other terms and conditions shall remain the same.

For the information and guidance of all authorized copy holders of the Bid Documents and prospective bidders.

For the Bids and Awards Committee:

ATTY. MELCHOR P. RIDULME
Vice President, Office of the Legal Counsel and
Chairman, Bids and Awards Committee

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SECTION VI

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EW-1.0 SOLAR PV SYSTEM

EW-1.1 Technical Specifications of the PV Components

This section provides the definition, functional/performance requirements, technical specifications and standards for the Solar PV modules, Mounting structures, Inverters, AC and DC switches and protections, etc.

EW-1.2 Solar PV Modules

a) The rated capacity of the solar PV module shall be based on its nameplate rating tested under Standard Test Conditions (STC). For bifacial type PV module, listed maximum power output at 0% bifacial gain on the nameplate shall be considered as the rated capacity of the module. The capacity of the Solar PV Plant shall be based on the total AC power output of the String Inverters.

b) The modules to be supplied shall have the same manufacturer, model, capacity and specifications for all installations required in this document, including required number of spares, if any, to avoid mismatch losses.

c) The solar PV modules shall be crystalline silicon type and shall have a minimum efficiency of 21% at 0% bifacial gain for bifacial type PV module.

d) The solar PV modules shall be designed, manufactured and tested in accordance with, but not limited to, the latest issue of the following codes and standards:

IEC	61215	Crystalline silicon (c-Si) terrestrial PV modules – Design qualification and type approval
IEC	61730-1	PV module safety qualification – Requirements for construction
IEC	61730-2	PV module safety qualification – Requirements for testing
IEC	61701	Salt mist corrosion testing of photovoltaic (PV) modules

A copy of the type qualification/test certificates of the PV module issued by authorized international organization in accordance with the abovementioned standards shall be submitted during post-qualification. Use of other standards shall be subject to the approval of the National Power Corporation.

e) The proposed Solar PV Module shall be sourced from a manufacturer included in the Tier 1 category listed by Bloomberg New Energy Finance as of bidding date. A copy of the Bloomberg list shall be submitted during post qualification.

f) The Solar PV modules shall be mounted on structures that are specified in this document and shall comply with NPC requirements.

g) In accordance with EN 50380 - Datasheet and nameplate information for photovoltaic modules, each module shall carry the following minimum information:

1. Name and logo of original manufacturer or supplier
2. Maximum system voltage
3. Rated nominal power (Pmax) at STC
4. Short circuit current (I_{SC}) at STC
5. Open circuit voltage (V_{OC}) at STC
6. Voltage at maximum power point (Vmax) at STC
7. Current at maximum power point (Imax) at STC

h) Protective devices against surges at the PV module shall be provided. By-pass diodes shall be provided in the PV modules.

i) Module Junction box shall be designed for long life outdoor operation and compliant to IP65 protection or approved equivalent.

j) The manufacturer of the Solar PV module shall be **ISO 9001 and ISO 14001** certified. A copy of the valid ISO certification shall be submitted during post-qualification.

k) The SPV modules shall have one make / model. Its outputs shall be within the tolerance of +/- 3% in each string to avoid array mismatch losses.

EW-1.3 String Inverters

a) The string inverters to be furnished shall be an on-grid type (grid following) solar inverter.

b) Each string inverter shall have at least one (1) Maximum Power Point Tracker (MPPT). The MPPTs shall automatically operate the Solar PV plant. It shall be microprocessor/microcontroller-based to minimize power losses and maximize energy utilization.

c) All inverters shall have the same manufacturer and model.

d) The inverter shall match the solar PV plant capacity while achieving optimum system efficiency. The total harmonic distortion shall not be more than 5%.

e) The efficiency of the inverter shall not be less than **95% at rated capacity.**

f) The inverter shall be equipped with a Modbus Interface.

g) Inverter shall be transformerless and IP65 degree of protection and shall comply with IEC 60529/UL50E. Climatic category shall comply with IEC60721-3-4 or IEC 60068.

h) The furnished inverters shall have built-in or installed controller or control functionalities that has provisions for integrations with higher levels of control/management systems.

i) The string inverters shall be of the grid-interactive type. It shall have protection against overvoltage and unintentional islanding that detects islanding conditions and automatically disconnects the system from the grid. The solar PV system will be automatically reconnected to the grid when the power has been restored.

j) The string inverters shall conform with, but not limited to, the latest issue of the following codes and standards.

IEC	62109-1	Safety of power converters for use in photovoltaic power systems – General Requirements
IEC	62109-2	Safety of power converters for use in photovoltaic power systems – Particular Requirements for inverters
IEC	62116	Utility-interconnected photovoltaic inverter – Test procedure of islanding prevention measures

A copy of the certification and approvals in accordance with the abovementioned standards shall be submitted during post-qualification. Use of other standards shall be subject to the approval of the National Power Corporation.

k) The inverter shall be rated for outdoor operation. It shall be placed away from direct sunlight and shall be provided with necessary housing or protection, if necessary, to ensure its maximum service life.

l) The inverter shall be able to provide logged data on power generated per period (configurable). The inverter shall have a minimum display parameters of AC output power, AC output voltage, AC output current, frequency, PV Array voltage, PV Array current (A), AC energy yield and Events/Errors.

m) The inverter load ratio shall be within 1.0 – 1.1 otherwise within the limits recommended by the manufacturer of the string inverter to avoid under and oversizing of the inverter.

n) Inverters shall have output curtailment functionalities. In the event that the Solar PV system production is at optimum, the energy storage batteries are fully charged, and the load demand is low, the inverter shall be able to control its output to match the prevailing demand.

EW-1.4 DC Boxes

a) The DC Boxes shall be dustproof, vermin and waterproof and sturdy and shall have at least IP65 Protection.

b) The DC Boxes shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Proper cable markings shall be provided for easy identification and cable ferrules shall be fitted at the cable termination points.

c) The DC Boxes shall have suitable arrangement for the following:

1. Incoming DC cables from the solar array
2. DC isolation switch/circuit breaker per String
3. At least type II DC surge protection device (SPD)
4. Outgoing DC cables to the string inverter
5. Provision for earthing

d) The DC Boxes shall be permanently marked and labeled. It shall have swinging doors or covers and shall be accessed by a lock or other approved means.

e) If the string inverters have a built-in DC protection/disconnect switch and DC SPDs (at least type II) per string, the Supplier shall still furnish a separate DC box, DC SPDs and disconnects.

f) The DC circuit breakers shall be Compact with Thermal Magnetic Trip Unit Type, Miniature Circuit Breaker (MCB). Rating of the circuit breakers shall be appropriate for the proposed design of the supplier. The rating of the breaker shall be verified by NPC for approval.

EW-1.5 AC Combiner Box

a) The AC combiner box shall be dust proof, vermin proof, waterproof, sturdy and shall be at least IP65 rated.

b) The AC combiner box shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Proper markings shall be provided on the bus bar for easy identification and cable ferrules shall be fitted at the cable termination points. The bus bars shall be made of copper of appropriate capacity with adequate safety factor.

c) The AC combiner box shall have suitable arrangement for the following:

1. Incoming cables from each string inverter
2. AC circuit breakers of each string inverter
3. Main AC circuit breaker
4. At least type II AC surge protection devices (SPD)
5. Digital Metering System
6. Outgoing cables to the low voltage side of the SPP Transformer
7. Provision for earthing

d) The AC combiner box shall be permanently marked and labeled. It shall have swinging doors or covers and shall be accessed by a lock or other approved means.

e) The AC combiner box shall be provided with digital metering system with display window capable to measure single and three phase electrical parameters through respective control switches. It shall be able to interface with the hybrid controller. Digital meter to be used shall meet the minimum specifications requirement stated in EW-1.6 SPP Digital Energy Meter.

f) The supplier shall provide adequate surge protection devices. If the string inverters have a built-in AC SPDs (at least type II), the Supplier may opt to supply a separate AC SPDs per inverter in the AC combiner box.

g) The AC circuit breakers shall be Compact with Thermal Magnetic Trip Unit Type, Molded Case Circuit Breaker (MCCB). Rating of the circuit breakers shall be appropriate for the proposed design of the supplier. The rating of the breaker shall be verified by NPC for approval.

EW-1.6 SPP Digital Energy Meter

This specification covers the technical and associated requirements for the SPP digital energy meter including instrument transformer and accessories required for the electric generating plants.

EW-1.6.1 Technical Characteristics and Requirements

The SPP digital energy meter shall be furnished and installed by the Supplier as shown on the bid drawings complete with stainless steel housing, test block and associated metering instruments transformers (current transformers) of appropriate burden and accuracy and other accessories for outdoor metering purposes. It shall be capable of measuring the power generated and received by the Solar PV Plant. It shall be designed to operate continuously for the normal life of the meter. The digital energy meter shall meet the following minimum requirements:

ITEM	DESCRIPTION	REQUIREMENTS
1	Number of Wires	3 or 4
2	Voltage, V	120-480
3	Accuracy class	0.5 or better
4	Current Range	Class 10
5	Frequency, Hz	60
6	Register Type	LCD
7	Soft Switches	Available
8	LCD Display	Programmable
9	The Kilowatt-hour meter to be provided is certified and approved by ERC	Yes
10	Communication Port for Kilowatt-hour meter	To be Provided
11	Meter Test Block	

	No. of Poles	10 (4 Voltage & 6 Current Terminals)
	Rated Voltage, V	600V
	Equipment Standard	ANSI C12.9
	Test Block Cover	Required
12	Metering Current Transformer	
	a. Application (Indoor/Outdoor)	Outdoor
	b. Insulation type	Full cast epoxy resin
	c. Primary rated current, A	80
	d. Secondary rated current for all windings, A	5
	e. No. of cores	One (1) core Secondary CT
	f. CT ratio	80:5 A
	g. Burden, VA	2.5
	h. BIL, kV	10

In extreme cases, the Supplier shall furnish, if necessary, outdoor type potential transformer with the same BIL rating. The transformer shall have appropriate voltage ratio suitable for the SPP digital energy meter. All costs associated with the supply and installation of such transformer shall be to the account of the Supplier.

The SPP digital energy meter shall have but not limited to the following features:

1. Pilferage proof
2. Tamper Proof
3. Wrong Wiring Alarm
4. Current Flow display
5. Can withstand the temperature of -20°C to +70°C and Humidity of up to 95% non-condensing
6. With back light display
7. With built-in battery for LCD display and back-up battery
8. TOU Programmable Ready
9. Measure display (Energy, RMS voltage & current per phase, Reactive & Apparent Power, Power factor, Frequency, Calendar, Time and etc.)

The Solar PV Plant (SPP) digital energy meter with the required metering instruments shall be enclosed by the distribution panel/AC box or, if needed, by a separate enclosure for proper protection and safety against water droplets, dust, exposure of energized conducting material and the like without additional cost to NPC.

For SPP digital energy meter, communication ports shall be provided or available in the energy meter exclusively intended for electronic reading, hence reading the data determined from the computer remotely from the meter. Electronically gathering of data can logged parameters to the computer such as instantaneous parameters, billing information, load survey, events or tampers, transactions, etc.

EW-1.7 DC and AC Switches

a) **DC Side**

1. Each string of the Solar PV shall be provided with a circuit breaker for isolation and maintenance purposes. Circuit breakers shall be listed for use in DC circuit and shall have the appropriate voltage, current and interrupting capacity ratings.

2. DC Circuit breakers shall be sized to carry not less than 125 percent of the maximum calculated current of the string/array.

b) **AC Side**

1. Main Circuit Breaker of appropriate rating shall be provided for connection and disconnection of Solar PV plant and the grid.

2. Each inverter shall be provided with circuit breakers. The rating of the circuit breakers shall be based on the output rating of the inverter.

EW-1.8 Power Cables and Accessories

a) Power cables of adequate current and voltage insulation rating shall be required for the interconnection of:

- Modules/panels within the PV array
- PV array and Inverter
- Inverter and AC combiner box

b) DC Power cables shall be suitable for outdoor installation, stranded tinned annealed copper conductor, UV & moisture resistant, flame retardant, halogen free crosslinked type insulation.

c) AC Power cables shall be suitable for outdoor installation with adequate abrasion, UV and water resistance. It shall have polyvinyl chloride insulation and covered with a tough protective sheath of nylon complying with UL standard or any equivalent. It shall be THHN/THWN-2 type with sizes intended for its use.

d) Size of all cables shall be selected to keep the voltage drop and losses to the acceptable minimum level. The permissible voltage drop on the DC side shall be ≤ 1% at full power.

e) The ampacity of the conductors shall be equal to or greater than the rating of the overcurrent protection device.

f) DC Cables shall be terminated with tinned copper end-ferrules to prevent fraying and breaking of individual wire strands. A marking near the terminals to indicate the destination of each cable shall be provided for future maintenance. It shall be designed for heavy duty operation, 1.5kV grade, insulated and stranded copper conductor. MC4 connectors shall conform with EN 50521 and Philippine Electrical Code

g) AC conductor shall be either of Class 1 or Class 2 of plain or metal-coated annealed copper of plain aluminum alloy, or of class 5 plain or metal-coated copper in accordance with IEC 60228. AC conductors shall be constructed and tested in accordance with IEC 60227 Part I & II.

h) All cables installation shall be provided with protective raceway. Proper cable management shall be observed to ensure maximum service life of the cables.

EW-1.9 Grounding and Surge Protection

a) The Solar PV power system & structures shall be grounded properly using adequate number of earthing kits (e.g., jumper wires, grounding plate and etc.). All metal casing or shielding, PV module frame and mounting structure of the Solar PV power system shall be grounded to ensure safety. Grounding materials/equipment and design shall comply in accordance with governing standards and regulations in grounding system (PEC, NEMA, IEC and IEEE standards).

b) All grounding and lightning conductors shall observe safe distance to prevent any damage to the equipment and property.

c) The Solar PV power system shall be provided with lightning & surge protection. The purpose of this protection is to reduce the over voltage to a tolerable value before it reaches the PV or other sub-system components. Lightning and surge materials/equipment shall comply in accordance with governing standards and regulations, (PEC, NEMA, IEC and IEEE standards).

d) The specification of lightning and surge protection shall provide optimum filtering in relation with the specification required by the proposed inverter and PV panels. The surge protection device must be compact and shall comply in accordance with the UL 1449 3rd edition testing, ANSI/IEEE C62 and ANSI/IEEE Std. 1100-1999.

e) Surge protection device shall be marked with a short circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating.

f) The Solar PV power plant shall be provided with an automatic ground-fault protection device or system. The ground – fault protection shall be capable of detecting a ground fault, providing an indication of the fault, interrupting the flow of fault current and automatically disconnects the conductors and/or shuts off the inverter for that portion faulted array.

EW-1.10 Solar PV Plant (SPP) Transformer

EW-1.10.1 General

This specification covers the technical and associated requirements for the SPP transformer and accessories for use in electric generating plants. The rating of this transformer is specified in the **Technical Data Sheets** and in ***GW***

–6.0 Supplier's Scope of Works. The supplied transformer shall be in accordance with the latest revision of IEEE Std. C57.12.00.

EW-1.10.2 Technical Requirements

The supplied SPP transformer for Calutcot Solar PV Plant shall meet the following minimum requirements:

ITEM	DESCRIPTION	REQUIREMENTS
1	Type of Cooling	ONAN
2	Insulation	Mineral Oil with its electrical and chemical characteristics is compliant with IEC and is Polychlorinated Biphenyls (PCB) free
3	Type	Two-winding Transformer
4	Audible Sound Level	Refer to Table specified under EW-1.10.3.8
5	Vector Group	YNd11
6	Temperature	
	a. Ambient Temperature	40°C
	b. Temperature Rise	65 °C
7	Winding Connection	
	• H-Winding	Wye with Neutral Grounded
	• X-Winding	Delta
8	Insulation Level	
	a. Nominal Voltage Level, kV	
	▪ H-winding	13.8
	▪ X-winding	0.48
	b. Highest Voltage Level, kV	
	▪ H-winding	15
	▪ X-winding	1.2
	c. Basic insulation level, kV	
	▪ H-winding	95
	▪ X-winding	30
9	Winding Material	100% Copper
10	Bushing Material	Porcelain
11	% Impedance at Rated kVA	Manufacturer's Data
12	Efficiency	
	a. At 100% load	By Supplier
	b. At 75% load	By Supplier
13	Tap Changer	No-Load
14	Taps	
	a. H-Winding	13.8 kV ± 2 x 2.5%
	b. X-Winding	N/A

15	Transformer Losses	
	a. No-Load Loss, W	By Supplier
	b. Load Loss, W	By Supplier
16	Tolerances	
	a. No-Load & Load Loss	Not more than 10% of the manufacturer's specified value
	b. Total Loss	Not more than 6% of the manufacturer's specified value
	c. Impedance	± 10% of the manufacturer's specified value
17	Ground Terminal Connection	Suitable for 100 mm^2 copper conductor
18	Weight of oil, kg	By Supplier
19	Total Weight, kg (with transformer oil)	By Supplier
20	Test and Experience Requirements	
20.1	Test Requirements[1]	
	a. Routine Test to be performed	Yes
	b. Certified Design and Routine Test Reports to be submitted	Yes

EW-1.10.3 Design Requirements

EW-1.10.3.1 Rating

The transformer rating specified in the Technical Data Sheets shall be the basis of the Supplier's guarantee as to performance and temperature rise. The ratings indicated are based on actual load requirements at the service and operating conditions specified herein.

EW-1.10.3.2 Voltage

The transformer to be supplied shall be designed to withstand the over voltages for the duration of voltage excursions which may be expected as a result of full load rejection of the inverters.

EW-1.10.3.3 Frequency

Frequency for operation shall be 60 Hz.

EW-1.10.3.4 Overload Requirement

The overload rating and operation shall be in accordance with all cyclic loading duties as specified in IEC 60076-7. The overload capability of any auxiliary

[1] *Test Report of a licenser instead of the Supplier's Manufacturer shall not be accepted.*

equipment such as bushings, LTC's, CT's, oil expansion tanks, leads, etc. shall not be less than the transformer overload rating. If other considerations will limit the overload capability of the transformer, the Supplier shall specify these limitations in his proposal.

EW-1.10.3.5 Short Circuit Withstand Capability

The transformer shall withstand the mechanical and thermal stresses produced by external short-circuit currents specified in IEEE Std. 57.12.00 (latest revision)

EW-1.10.3.6 Transformer Loss Evaluation

Depending on the requirement stated in the Technical Data Sheets, the Supplier is required to fill-in all the information for the transformer losses in the Technical Data Sheets for the SPP transformer for NPC to fully determine the most cost effective of the proposed transformer(s) to be supplied considering both cost of losses and first cost.
The transformer shall be designed for the most economical loss ratio (copper loss/iron loss) for the application as specified in the Technical Data Sheets for the transformer.

EW-1.10.3.7 Impedance and Reactance

The impedance and reactance shall be stated in the Proposal.

EW-1.10.3.8 Audible Sound Level

Sound levels decibels (dB) at rated voltage and frequency for liquid immersed SPP transformer shall be as below. The average sound level of the transformer shall not exceed these values when measured in accordance with the conditions outlined in the latest ANSI/IEEE C57.12.90 or IEC 60076-10 for oil-immersed transformers.

Equivalent Two-winding, kVA	Average Sound Level, dB
1-50	48
51-100	51
101-300	55
301-500	56
750	57
1000	58
1500	60
2000	61
2500	62

EW-1.10.3.9 Tolerances

The transformer shall be designed and manufactured with tolerances in accordance with applicable ANSI/IEC/IEEE standards.

EW-1.10.3.10 Electrical Insulating Oil

The Supplier shall furnish oil with quality suitable as an insulant and coolant for transformers. The oil shall be new naphthenic based mineral oil meeting the requirements of the latest ASTM D3487 (Specification of Mineral Insulating Oil Used in Electrical Apparatus).

Insulating liquid must not contain more than 2PPM of Polychlorinated Biphenyl (PCB), classified as "PCB free". The Supplier shall submit a certification from the manufacturer of the transformer that the transformer oil does not contain PCB and the laboratory analysis shall be conducted by a DENR-Accredited Laboratory.

The Supplier shall state the commercial name and specifications of the oil to be furnished. NPC reserves the right in the future to use any oil which meets the above specifications and the use of such oil shall not affect the Supplier's guarantee.

EW-1.10.4 Design and Construction Features

EW-1.10.4.1 General

The transformer design, manufacture and assembly shall minimize vibration and shall prevent damage by inherent vibration and stress during operation, transportation and short circuits.

EW-1.10.4.2 Cores

Cores for the transformers shall be constructed of the highest quality, non-aging high permeability grain oriented silicon steel. The steel shall be in thin laminations, annealed after cutting and rolled to ensure smooth surface at the edges.

The laminations must be free from impurities and must receive stress relief treatment after punching. The laminations shall be accurately flattened, especially at the edges and insulated by suitable procedures with long life heat resistant insulating coat.

Both sides of each sheet shall be insulated with a durable, heat resistant insulation. The cores shall be held firmly by core clamp and brace to ensure adequate mechanical strength to support the winding and to withstand without damage or deformation, the forces, caused by short circuit stresses, transportation or handling to prevent shifting of the core laminations.

The core shall be solidly grounded to the tank and shall be provided with approved lifting devices or lifting lugs at suitable points of the core assembly for core lifting.

EW-1.10.4.3 Windings

Windings for transformer shall be of the best modern design of conductor having constant cross-section and uniform insulation or graded insulation as

required. The coils shall be wound and supported in a manner to provide sufficient oil ducts which will be maintained without constriction.

End coils shall have extra insulation. Coils shall be made up, shaped and braced to provide for expansion and contraction due to temperature changes in order to avoid abrasion of insulation and provide rigidity to resist movement and distortion caused by abnormal operating conditions.

Adequate barriers shall be provided between windings and core and between high and low voltage windings. End coils shall have extra protection against abnormal line disturbances. Permanent current-carrying joint for splices shall be welded or brazed, properly formed and finished, and insulated to conform to the basic insulation.

Winding conductor shall be free from scars, burrs and splinters and shall be uniformly insulated.

The completed assembly of core and coils shall be vacuum dried, immediately impregnated and immersed in dry oil. They shall be adequately braced to withstand ocean shipment, short-circuit forces and earthquakes.

EW-1.10.4.4 Bushing

All porcelains used in bushing shall be wet process, homogenous, and free from cavities or other flaws. The glazing shall be uniform in color and free from blisters, burrs and other defects. All porcelain parts shall be one piece. The bushings of the same rating shall be interchangeable.

Bushing up to 110 kV BIL shall be porcelain bulk type whereas bushings above 110 kV BIL shall be condenser-type. In the latter case, the bushing shall be provided with capacitance test tap.

Bushings shall have the continuous current-carrying capacity necessary to carry the full 65^{0}C temperature rise. The bushings shall also be capable of carrying overload currents as required by EW-1.10.3.4.

The terminal pads shall be of high conductivity bronze or copper and shall be plated with hot flowed electro silver or electro-tin. Whenever a larger terminal pad is required for higher current rating, the mounting holes shall conform to NEMA Standards.

The HV and LV terminations of the SPP transformer shall be fitted with suitable insulating shroud. The insulating shrouds shall be manufactured through dip moulding process and shall be made from flexible polyvinyl chloride (PVC) material, suitable for low voltage to high voltage applications. The insulating shroud shall be flame retardant, conforming with the UL 94 Standards. They shall be type tested for electric strength in accordance with IEC 60243-1 or approved equivalent standards.

EW-1.10.4.5 Gasket

Gaskets shall be unaffected by hot insulating oil, retain their resiliency during the life of the associated equipment, and be unaffected by weather while maintaining oil and gas tightness. Nitrile rubber gaskets are acceptable.

Gaskets of neoprene and/or any kind of impregnated/bonded cork or cork only are not acceptable. Gasket flanges shall have grooves or metal stops to prevent over compression of gaskets. All bolted transformer tank or accessory openings shall be gasketed.

EW-1.10.4.6 Tank

The transformers shall be housed in a steel tank with all permanent joints molded, backed up by a sturdy steel structure as required to obtain the desired rigidity and strength. The material shall be of high grade steel plate having good welding qualities. All seams, flanges, lifting and jacking lugs, braces and other parts attached to the tank shall be welded. No rivets shall be used. The cover shall be bolted type. The tank shall be able to withstand an internal pressure with oil at operating level.

All openings such as joint between the case and cover, bushings, insulation mountings, etc., shall have welded on flanges to provide gaskets surfaces and allow for bolt holes. No bolts shall pass to the inside of the case and cover. Flanges shall have gaskets which will remain oil-tight and will not deteriorate under severe conditions. The tank with radiator fitted shall be tested for leaks before painting.

EW-1.10.4.7 Radiators

Radiators, if to be provided, shall be bolted to the main transformer tank and readily detachable. Isolation valves shall be fitted to the tank to permit radiator removal without draining the main tank. Separate filling plugs, air bleed plugs and drain plugs shall be fitted to each radiator section. Radiators shall be galvanized externally prior to etching and painting. Particular attention shall be given to their internal cleaning and painting to ensure that the radiators arrive in a serviceable condition. All radiators shall be completely sealed with blanking plates and neoprene seals for transport. They shall be thoroughly dried before shipment.

EW-1.10.4.8 Hardware

All energized hardware, i.e., bolts, nuts and washers shall be made of tinned copper alloy material such as silicon bronze or equivalent. All other hardware shall be hot-dip galvanized.

EW-1.10.5 Fittings and Accessories

The following transformer accessories shall be included:

a) HV Bushing
b) Oil Level Indicator
c) Oil Sampling Plug
d) Oil Drain Valve
e) Oil Temperature Indicator
f) Pressure Relief Valve
g) Lifting Lugs
h) Anchor Bolts
i) Earthing Terminals
j) HV/LV Insulating Shroud

EW-1.10.6 Equipment and Marking

The transformer shall be provided with a stainless steel nameplate in accordance with the latest standard of IEC60076-1, fitted in a visible position showing the information indicated below. The entries on the plate shall be indelibly marked.

a) Kind of transformer
b) Number of this standard
c) Manufacturer's name
d) Manufacturer's serial number
e) Year of manufacture
f) Number of phases
g) Rated power (in kVA or MVA)
h) Rated frequency (in Hz)
i) Rated voltages (in V or kV) and tapping range
j) Rated currents (in A or kA)
k) Connection symbol
l) Short circuit impedance (in %Z)
m) Type of cooling (i.e., OA, ONAN, etc.)
n) Insulation voltage (withstand voltages)
o) Insulating liquid
p) Temperature rise (in °C)
q) Total mass, kg
r) Mass of insulating oil

The minimum recommended dielectric strength of oil filling the transformer shall also be engraved on this plate. The rating plate and any other instructions or designations shall be in the English language.

EW-1.10.7 Standard and Common Tools

The Manufacturer of transformer shall provide standard/common tools for use in the installation/maintenance of transformer.

EW-1.10.8 Tests

All tests shall be performed as per latest revision of ANSI C57.12.90 Factory Test shall include, but not limited to the following:

EW-1.10.8.1 Routine Test

1. Ratio, Polarity and Phase Relation Test
2. No Load Losses and Excitation Current at rated Voltage and Frequency
3. Induced Potential Test (Low-frequency Dielectric Test)
4. Mechanical (Leak Test)

EW-1.10.8.2 Design Test

1. Winding Resistance Measurement Test
2. Impedance Voltage and Load Loss Measurement
3. Temperature Rise
4. Lightning Impulse
5. Audible Sound Level

6. Mechanical (Lifting & Moving Devices, Pressure Test)

EW-1.10.8.3 Miscellaneous Test

1. Insulation Power Factor
2. Insulation Resistance
3. Short Circuit Capability

EW-1.10.8.4 Site Test

The Supplier shall perform all tests specified by the equipment Manufacturer, applicable standards and as necessary to verify the proper operation of the equipment in the presence of NPC representatives.

1. Check level and alignment of the installed transformer;
2. Check tightness of connections and fastenings;
3. Check proper grounding;
4. Check oil level monitors, nameplate, vent plugs;
5. Check wire and cable connections;
6. Check cable glands and entrance;
7. Check on the proper installation of transformer accessories;
8. Winding resistance;
9. Insulation Resistance;
10. Transformer Turns Ratio;
11. Dielectric Test; and
12. Insulation Power Factor or Dissipation Factor.

EW-1.10.9 Failure to Meet Guarantees

Depending on the requirement stated in the Technical Data Sheets, the transformer will be tested for compliance with the Manufacturer's guaranteed losses. If the transformer losses, as determined by test, at rated voltage, frequency and 100% rated kVA exceed the guaranteed total losses, the excess in losses shall be evaluated at the following rated cost and the resulting amount shall be deducted from the contract price.

$$S = 2\,[(N_{L\text{-}L})\,(N_{LM} - N_{LG}) + (L_L)\,(L_{LM} - L_{LG})]$$

Where:

S = Amount to be deducted from the Contract Price

$N_{L\text{-}L}$ = Price in Php/Watt for the no-load losses as stated in the Technical Data Sheets

N_{LM} = Measured no-load losses expressed in Watt

N_{LG} = Guaranteed no-load losses as stated on the Technical Data Sheets

L_L = Price in Php/Watt for the load losses as stated in the Technical Data Sheets

L_{LM} = Measured load losses expressed in Watt

L_{LG} = Guaranteed load losses as stated on the Technical Data Sheets

When the excess of the total losses reaches five percent (5%), NPC shall have the right to reject the transformer for which such excess is verified during the factory acceptance test.

Successful Bidder shall promptly provide NPC one (1) original and three (3) certified copies of all test data and reports on the transformer.

EW-1.10.10 Data and Documentation Requirements

The following documents shall be submitted after award of contract for NPC's review and approval prior to procurement and installation of the supplied equipment and materials:

1. Outline drawings of transformer and accessories showing the following:

    a) General Dimensional Drawing
    b) Sectional Drawing
    c) Nameplate Drawing
    d) Marshaling box with connection diagram

2. Description and instructions covering the installation, operation and maintenance of the transformer and accessories;

3. Duly signed Routine Test Results; and

4. Field Test to be Performed and Certified Test and Inspection Reports duly signed and witnessed by NPC representative

EW-1.11 Job Site Cameras

This specification covers the supply, delivery and installation of job site cameras for the use in monitoring and documenting the construction of Solar PV Plant and Energy Storage System.

The materials to be furnished shall be in accordance with, but not limited to, the latest issues of the Applicable Codes and Standards, including all addenda, in effect at time of purchase order unless otherwise stated herein.

EW-1.11.1 Technical Characteristics

The job site cameras to be supplied shall be DC supply operated and battery-operated cameras. It shall be designed to monitor the construction of SPP, ESS and access areas for a routine documentation.

At least two (2) sets of job site cameras must be installed before works shall be done in the project sites. Exact placement/location of cameras shall be approved by NPC.

The Supplier shall define the focusing ranges and allowable minimum distance in accordance with the layout at site.

In normal operation, the job site camera provides monitoring of the construction sites. For full coverage of the cameras, the job site cameras shall be installed in an elevated area within the site while is out of reach of the construction

equipment. It shall include supports and mounting poles (if required) for the ease of the installation.

The job site cameras must have the functionality and adaptability in the construction site. It shall have a 100% reliability without affecting the implementation.

The Supplier shall ensure that the job site cameras they supply, functions correctly and safely. In principle, the installation shall follow the latest modern engineering practice, ensure optimum functionality of supply and ensure the safety of the construction staff.

Job site cameras shall be subject to the approval of NPC.

All job site cameras shall meet the technical requirements in the specifications. It shall have a dustproof and weather resistant protective enclosure complying with the technical requirements.

EW-1.11.2 Technical Requirements

The supplied Job Site Cameras shall meet the following minimum technical requirements:

	DESCRIPTION	NPC REQUIREMENTS
1	Type	Time-Lapse Camera
2	Quantity	As specified in the TDS and SOR
3	Control Display	Thin-Film-Transistor (TFT) Liquid Crystal Display (LCD)
4	Image Sensor Resolution	At least 1.3 Megapixel CMOS
5	View Angle	At least 110 degrees
6	Still Image Resolution	1280 x 720
7	Time Lapse Interval	15 minutes/ User-programmable
8	Battery Type	Standard AA or AAA Sized Alkaline Batteries
9	Battery Life	At least 120 days of image recording
10	Additional Batteries (Spare)	To Be Provided
11	Enclosure	IPX4 compliant
12	Storage Memory	SDHC
13	Storage Capacity	32 GB
14	Additional Storage per camera (Spare)	At least one (1)

When the installation of the job site cameras is completed, the operation and safekeeping shall be turned over to NPC.

The Supplier shall provide sufficient number of spare alkaline batteries to operate the construction cameras through the entire contract duration. In case of contract extension, the required additional batteries shall also be provided until contract completion at no additional cost to NPC.

EW-1.12 Measurement of Payment

Measurement of payment for all electrical works shall be based on the bid price of each item as shown in the Schedule of Requirements – Electrical Works, Section VII of the Bid Document. The cost of each item shall cover all works required and described in the pertinent provisions of the specifications.

SECTION VI

PART I-TECHNICAL SPECIFICATIONS

ELECTRICAL WORKS

EW 2.0 – ENERGY STORAGE SYSTEM

PART I – TECHNICAL SPECIFICATIONS

EW – ELECTRICAL WORKS

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PART I – TECHNICAL SPECIFICATIONS

EW – ELECTRICAL WORKS

EW-2.0 ENERGY STORAGE SYSTEM

This section provides the definition, scope of works, functional/ performance requirements, technical specifications, and standards for the Energy Storage System (ESS).

EW-2.1 Definition of Terms

a) ***State of Charge (SoC)*** is the level of charge of a battery system/ module measured from 0%. 0% SoC refers to a fully discharged battery and 100% SoC refers to a fully charged battery.

b) ***Depth of Discharge (DoD)*** is the level of charge of the battery system/ module measured from 100% SoC. 100% DoD refers to a fully discharged battery and 0% DoD refers to a fully charged battery.

c) ***Maximum Normal State of Charge (MaxNSoC)*** is the SoC at which the ESS can be charged at maximum rate (i.e., prior to taper/trickle charge).

d) ***Minimum Normal State of Charge (MinNSoC)*** is the SoC specified by the ESS/battery manufacturer at which the ESS can inject power to the interconnection point at full rated power. At MinSoC, the ESS must be able to inject full power for at least 5 seconds.

e) ***Usable Range of SoC*** is the range between MaxNSoC and MinNSoC.

f) ***Usable Energy*** is the kWh capacity available of the Usable Range of SoC.

g) ***State of Health (SoH)*** is an indicator of the remaining capacity of the battery system/module to deliver the required Usable Energy. It shall reflect the remaining life, in equivalent full cycles of the battery, and indicate if the battery system/ module need replacement.

h) ***Beginning of Life (BoL)*** is the instance that ESS begins operation during conduct of Commissioning Tests.

i) ***End of Life (EoL)*** is defined as the instance where the Usable Energy falls below the required value as determined by the SoH indicator and/or a performance test.

j) ***Cycle Lifetime*** is the number of full charge and discharge cycles between the EoL and BoL at nominal C rating @25°C.

k) ***Power Conversion System (PCS)*** refers to the subsystem of the ESS that contains inverter(s), power electronics, circuit breakers, transformers, switchgears and safety systems required for the ESS to inject and absorb electricity between the interconnection point (e.g., busbar) and the battery system.

l) ***ESS Control System (ECS) / ESS controller*** refers to the control system of the ESS.

m) ***Battery Management System (BMS)*** refers to the sub-system of the ESS that monitors and controls the battery units and ensures proper charge and discharge of the battery modules.

n) ***Battery modules*** are the smallest modules/ unit of energy storage that is user replaceable without the use of specialized tools and equipment. They are made of individual battery cells connected in series/parallel or combination thereof.

o) ***Energy Storage System (ESS)*** refers to the system responsible for the storage and discharge of electricity depending on the power system requirements. It is composed of the following sub systems:

- Battery Management System
- Battery Modules / Batteries
- Power Conversion Systems / Battery Inverter
- ESS Control System / ESS Controller
- ESS Transformer

EW-2.2 Scope of Works

The general scope of work is enumerated below. Additional details are provided in the relevant sections of the tender.

a) All services, materials, and equipment necessary for the proper installation, maintenance, and operation of the ESS. (e.g., ESS enclosure/cabinet, ESS transformer, communication, control and power cabling, cable trays, conduits, connection hardware, safety, and protection equipment, etc.).

b) The ESS shall be supplied and integrated as a complete operational equipment/system consisting of its appurtenances, tools, sub-systems, firmware, and software; including all items not specifically mentioned but are essential to the proper operation of the ESS as required herein. **The BMS, batteries and its racks shall be supplied together under one brand/manufacturer.**

c) Back-to-back guarantee/warranty with equipment manufacturer(s). Supplier shall provide/extend all warranties provided by the manufacturer to NPC. In case the supplier is unable to rectify/remedy defects in the product, they shall shoulder all expenses that the manufacturer may levy to remedy/rectify the defects.

d) Complete documentation:

- Design and as-built drawings.
- Installation, Operation and Maintenance Manuals
- Electrical circuit diagrams
- Performance Monitoring Test, Factory and Site Acceptance Test procedures.
- Back-up copies of control programs (firmware and other configuration software)

- Other relevant documents (if any).

e) Training of plant and technical services personnel regarding ESS as part of the plant as specified in *GW-14.0 Training of NPC Personnel.*

EW-2.3 Site Conditions

a) Environmental Conditions (refer to Section VI – GW 5.0, Design & Duty Conditions)

b) The ESS enclosure/cabinet shall have a footprint/area adequate to house all the major and appurtenant equipment of ESS (considering clearance requirements from adjoining equipment and structures). Refer to Section IX – Bid Drawings, Proposed Equipment Layout for the allocated space for the ESS.

EW-2.4 Energy Storage System (ESS)

The ESS shall mainly function as **grid stabilization equipment** by providing ancillary services. It shall support the operation of the whole power plant by providing buffer power in the event there is power and/or frequency fluctuations (e.g., Power output of the solar plant suddenly drops due to shading caused by cloud formation).

It shall have a power rating of *(refer to Section VI – GW 6.0 Supplier's scope of works)* (continuous) and a usable energy of at least *(refer to Section VI – GW 6.0 Supplier's Scope of Works)*.

Bi-directional (Import and Export) Digital Energy Meter shall be provided to account for energy import and export to and from the ESS. It shall be connected to the 3-phase, 60Hz system between the ESS and the ESS transformer.

The operating voltage of the ESS and the output voltage of the PCS respectively shall depend on the equipment manufacturer's specifications. However, the high voltage side of the ESS transformer shall be 13.8kV (line to line).

Roundtrip efficiency of the ESS must be at least 80%. Efficiency shall include/account the energy utilized by the cooling system, lighting, BMS, PCS and ECS/ESS Controller.

Detailed specifications of its components are provided in the succeeding sections.

EW-2.4.1 Battery Management System (BMS)

The BMS shall control and monitor all battery module parameters. e.g., SoC/DoD, string/module voltage, current, temperature, impedance (or equivalent parameter to indicate the "health" of the battery modules).

SoH data shall be available while the ESS is in operation and shall be revalidated by a performance test to be conducted at least once a year (or as the need arises).

The BMS shall automatically control the charge/discharge of all batteries including cell balancing, equalization and other maintenance and safety functions/procedures to ensure proper operation of the battery system. The same function can be triggered manually if necessary.

a) The BMS must be capable of keeping the operational history of individual battery modules. Operation of the battery module shall be managed individually to account for different module characteristics Minimum parameters to be logged are as follows:

- Module voltage
- Module current
- Replacement history of battery module
- Module faults/alarms
- Module temperature
- State of Charge (SoC) / Depth of Discharge (DoD)
- State of Health

b) The bidder/manufacturer shall specify the MinNSoC and MaxNSoC as defined in EW-2.1 of this section.

EW-2.4.2 Battery Modules/Batteries

a) Usable Energy of the batteries shall be at least *(refer to Section VI – GW-6.0 Supplier's scope of works)* within the warranty period. Testing shall be performed during factory acceptance, commissioning and at least once a year, or as the need arises (i.e., performance test) to ascertain the amount of usable energy. Bidder/manufacturer shall provide all test procedures subject to review and approval of the National Power Corporation.

b) Batteries shall have a minimum cycle lifetime of at least 5000 cycles @ nominal C-rate @25°C. The nominal C-rate of the battery to be supplied shall be 1C or higher. Batteries that have lower nominal C-rate shall be acceptable if these are configured in parallel to meet the equivalent rated power as the batteries with 1C rating. For example, 0.5C rated batteries with 60kWh energy capacity shall be connected in parallel with another identical module to meet the equivalent 1C rated batteries with 60kWh energy capacity. **It shall self-discharge for not more than 10% of its capacity per month**. The remaining cycles shall be translated into the SoH indicator parameter. This model shall be implemented in the BMS and shall be validated and adjusted (if necessary) during the conduct of annual performance tests.

c) Battery cells shall be prismatic format with an acceptable battery chemistry such as Lithium Manganese Oxide (LiMn2O4–LMO), Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO2–NMC), blended NMC/LMO and Lithium Ferrous Phosphate (LiFePO4–LFP).

d) Battery Modules shall be self-contained, modular and replaceable. For purposes of transportation, installation and maintenance, the Supplier shall provide specialized lifting equipment whenever the gross weight of each battery module exceeds to 60kgs.

e) Each battery module (if possible, each cell) shall be equipped with overcharge, short circuit, and thermal runaway protection. Each battery rack shall be protected by fuse and/or by DC circuit breaker against

electrical fault, this also serves as the main disconnecting means for repair and maintenance.

f) Batteries must be compliant to IEC 62619 or UL 1642. Test certificate of the batteries shall be submitted during post-qualification.

EW-2.4.3 Power Conversion System (PCS) / Battery Inverter

a) The PCS shall have the following functionalities:

- Parallel operation;
- Capable to provide ancillary services;
- Provide Short Circuit Current sufficient to trigger circuit breakers and other protection devices for duration of not less than 50ms;
- Provision of reactive power; and
- Fault ride through with programmable voltage and duration.

b) The PCS shall have a nominal power rating (net of ESS auxiliary power requirements) with 110% overload capability of at least ten (10) minutes.

c) PCS must be able to perform Power Swing necessary to compensate for sudden loss of generation from either the diesel generators or the solar PV plant.

d) The PCS shall have the capability to support the changes in power direction of the battery (from charge to discharge and vice versa) within 200ms.

EW-2.4.4 ESS Control System (ECS) / ESS controller

a) The ECS / ESS controller shall serve as the interface between the Hybrid controller and the ESS. It shall ensure that the ESS is able to respond to the commands of the Hybrid controller in performing all its functional requirements as specified herein.

b) The ECS / ESS controller shall be equipped with its own control interface that can display the status of the ESS and its components. The interface must be capable of monitoring operational and maintenance history of the ESS (of the SoC and "health" of each battery module).

EW-2.4.5 ESS Digital Energy Meter

This specification covers the technical and associated requirements for the ESS digital energy meter including instrument transformer and accessories required for the electric generating plants.

EW-2.4.5.1 Technical Characteristics and Requirements

The ESS digital energy meter shall be furnished and installed by the Supplier as shown on the bid drawings complete with stainless steel housing, test block and associated metering instrument transformers (current transformers) of appropriate burden and accuracy and other accessories for outdoor metering

purposes. It shall be capable of measuring the power generated and received by the ESS. It shall be designed to operate continuously for the normal life of the meter. The digital energy meter shall meet the following minimum requirements:

ITEM	DESCRIPTION	REQUIREMENTS
1	Number of Wires	3 or 4
2	Voltage, V	120-480
3	Accuracy class	0.5 or better
4	Current Range	Class 10
5	Frequency, Hz	60
6	Register Type	LCD
7	Soft Switches	Available
8	LCD Display	Programmable
9	The Kilowatt-hour meter to be provided is certified and approved by ERC	Yes
10	Communication Port for Kilowatt-hour meter	To be Provided
11	Meter Test Block	
	No. of Poles	10 (4 Voltage & 6 Current Terminals)
	Rated Voltage, V	600V
	Equipment Standard	ANSI C12.9
	Test Block Cover	Required
12	Metering Current Transformer	
	a. Application (Indoor/Outdoor)	Outdoor
	b. Insulation type	Full cast epoxy resin
	c. Primary rated current, A	By Supplier
	d. Secondary rated current for all windings, A	5
	e. No. of cores	One (1) core Secondary CT
	f. CT ratio	By Supplier
	g. Burden, VA	2.5
	h. BIL, kV	10

In extreme cases, the Supplier shall furnish, if necessary, outdoor type potential transformer with the same BIL rating. The transformer shall have an appropriate voltage ratio which is suitable for ESS digital energy meter and ESS AC voltage system. All costs associated with the supply and installation of such transformer shall be to the account of the Supplier.

The ESS digital energy meter shall have but not limited to the following features:

1. Pilferage proof
2. Tamper Proof

3. Wrong Wiring Alarm
4. Current Flow display
5. Can withstand the temperature of -20°C to +70°C and Humidity of up to 95% non-condensing
6. With back light display
7. With built-in battery for LCD display and back-up battery
8. TOU Programmable Ready
9. Measure display (Energy, RMS voltage & current per phase, Reactive & Apparent Power, Power factor, Frequency, Calendar, Time and etc.)

The ESS digital energy meter with the required metering instruments shall be enclosed by a separate enclosure for proper protection and safety against water droplets, dust, exposure of energized conducting material and the like without additional cost to NPC.

For ESS digital energy meter, communication ports shall be provided or available in the energy meter exclusively intended for electronic reading, hence reading the data determined from the computer remotely from the meter. Electronically gathering of data can be logged parameters to the computer such as instantaneous parameters, billing information, load survey, events or tampers, transactions, etc.

EW-2.4.6 ESS Enclosure/Cabinet

a) The ESS shall be self-contained in its own free-standing enclosure/cabinet. It shall be supported with a suitable foundation. The ESS enclosure/cabinet shall have a footprint/area adequate to house all the major and appurtenant equipment of ESS (considering clearance requirements from adjoining equipment and structures).

For enclosure integrated by the ESS manufacture to package the system into a single compact or multiple containerized housing shall be permitted provided that it is rated for outdoor operation with a minimum required IP rating and shall comply all applicable provisions thereon.

b) The ESS shall be equipped with a built-in redundant cooling system to control and maintain the temperature required inside the battery compartment. It shall be tropicalized and can operate automatically. It shall be configurable and programmable to be able to reboot and operate itself with automatic switchover, whenever there is a fault on the first cooling equipment, without human intervention (e.g., manual switching).

c) ESS enclosure/cabinet shall be rated at least IP55 and 2-hour fire rating.

d) The ESS shall have adequate protection to prevent unauthorized access to the ESS.

e) ESS shall be equipped with emergency stop buttons outside the enclosure/cabinet.

f) ESS enclosure/cabinet together with its enclosed non-current carrying metal shall be connected to ground and protected from any unexpected electricity leakage.

EW-2.4.7 ESS Transformer

EW-2.4.7.1 General

This specification covers the technical and associated requirements for the ESS transformer and accessories for use in electric generating plants. The rating of this transformer is specified in the **Technical Data Sheets** and in ***GW –6.0 Supplier's Scope of Works***. The supplied transformer shall be in accordance with the latest revision of IEEE Std. C57.12.00.

EW-2.4.7.2 Technical Requirements

The supplied ESS transformer for Calutcot Energy Storage System shall meet the following minimum requirements:

ITEM	DESCRIPTION	REQUIREMENTS
1	Type of Cooling	ONAN
2	Insulation	Mineral Oil with its electrical and chemical characteristics is compliant with IEC and is Polychlorinated Biphenyls (PCB) free
3	Type	Two-winding Transformer
4	Audible Sound Level	Refer to Table specified under EW-2.4.7.3.8
5	Vector Group	YNd11
6	Temperature	
	a. Ambient Temperature	40°C
	b. Temperature Rise	65 °C
7	Winding Connection	
	• H-Winding	Wye with Neutral Grounded
	• X-Winding	Delta
8	Insulation Level	
	a. Nominal Voltage Level, kV	
	▪ H-winding	13.8
	▪ X-winding	By Supplier
	b. Highest Voltage Level, kV	
	▪ H-winding	15
	▪ X-winding	By Supplier
	c. Basic insulation level, kV	
	▪ H-winding	95
	▪ X-winding	By Supplier
9	Winding Material	100% Copper
10	Bushing Material	Porcelain
11	% Impedance at Rated kVA	Manufacturer's Data

12	Efficiency	
	a. At 100% load	By Supplier
	b. At 75% load	By Supplier
13	Tap Changer	No-Load
14	Taps	
	a. H-Winding	13.8 kV ± 2 x 2.5%
	b. X-Winding	N/A
15	Transformer Losses	
	a. No-Load Loss, W	By Supplier
	b. Load Loss, W	By Supplier
16	Tolerances	
	a. No-Load & Load Loss	Not more than 10% of the manufacturer's specified value
	b. Total Loss	Not more than 6% of the manufacturer's specified value
	c. Impedance	± 10% of the manufacturer's specified value
17	Ground Terminal Connection	Suitable for 100 mm^2 copper conductor
18	Weight of oil, kg	By Supplier
19	Total Weight, kg (with transformer oil)	By Supplier
20	Test and Experience Requirements	
20.1	Test Requirements[1]	
	a. Routine Test to be performed	Yes
	b. Certified Design and Routine Test Reports to be submitted	Yes

EW-2.4.7.3 Design Requirements

EW-2.4.7.3.1 Rating

The transformer rating specified in the Technical Data Sheets shall be the basis of the Supplier's guarantee as to performance and temperature rise. The ratings indicated are based on actual load requirements at the service and operating conditions specified herein.

EW-2.4.7.3.2 Voltage

The transformer to be supplied shall be designed to withstand the over voltages for the duration of voltage excursions which may be expected as a result of full load rejection of the inverters.

[1] *Test Report of a licenser instead of the Supplier's Manufacturer shall not be accepted.*

EW-2.4.7.3.3 Frequency

Frequency for operation shall be 60 Hz.

EW-2.4.7.3.4 Overload Requirement

The overload rating and operation shall be in accordance with all cyclic loading duties as specified in IEC 60076-7. The overload capability of any auxiliary equipment such as bushings, LTC's, CT's, oil expansion tanks, leads, etc. shall not be less than the transformer overload rating. If other considerations will limit the overload capability of the transformer, the Supplier shall specify these limitations in his proposal.

EW-2.4.7.3.5 Short Circuit Withstand Capability

The transformer shall withstand the mechanical and thermal stresses produced by external short-circuit currents specified in IEEE Std. 57.12.00 (latest revision).

EW-2.4.7.3.6 Transformer Loss Evaluation

Depending on the requirement stated in the Technical Data Sheets, the Supplier is required to fill-in all the information for the transformer losses in the Technical Data Sheets for the ESS transformer and station service/dry-type transformer in order for the NPC to fully determine the most cost effective of the proposed transformer(s) to be supplied considering both cost of losses and first cost.

The transformer shall be designed for the most economical loss ratio (copper loss/iron loss) for the application as specified in the Technical Data Sheets for the transformer.

EW-2.4.7.3.7 Impedance and Reactance

The impedance and reactance shall be stated in the Proposal.

EW-2.4.7.3.8 Audible Sound Level

Sound levels decibels (dB) at rated voltage and frequency for liquid immersed ESS transformer shall be as below. The average sound level of the transformer shall not exceed these values when measured in accordance with the conditions outlined in the latest ANSI/IEEE C57.12.90 or IEC 60076-10 for oil-immersed transformers or ANSI/IEEE C57.12.91 or IEC 60726 for dry-type transformers.

Equivalent Two-winding, kVA	Average Sound Level, dB
1-50	48
51-100	51
101-300	55

301-500	56
750	57
1000	58
1500	60
2000	61
2500	62

EW-2.4.7.3.9 Tolerances

The transformer shall be designed and manufactured with tolerances in accordance with applicable ANSI/IEC/IEEE standards.

EW-2.4.7.3.10 Electrical Insulating Oil

The Supplier shall furnish oil with quality suitable as an insulant and coolant for transformers. The oil shall be new naphthenic based mineral oil meeting the requirements of the latest ASTM D3487 (Specification of Mineral Insulating Oil Used in Electrical Apparatus).

Insulating liquid must not contain more than 2PPM of Polychlorinated Biphenyl (PCB), classified as "PCB free". The Supplier shall submit a certification from the manufacturer of the transformer that the transformer oil does not contain PCB and the laboratory analysis shall be conducted by a DENR-Accredited Laboratory.

The Supplier shall state the commercial name and specifications of the oil to be furnished. NPC reserves the right in the future to use any oil which meets the above specifications and the use of such oil shall not affect the Supplier's guarantee.

EW-2.4.7.4 Design and Construction Features

EW-2.4.7.4.1 General

The transformer design, manufacture and assembly shall minimize vibration and shall prevent damage by inherent vibration and stress during operation, transportation and short circuits.

EW-2.4.7.4.2 Cores

Cores for the transformers shall be constructed of the highest quality, non-aging high permeability grain oriented silicon steel. The steel shall be in thin laminations, annealed after cutting and rolled to ensure smooth surface at the edges.

The laminations must be free from impurities and must receive stress relief treatment after punching. The laminations shall be accurately flattened, especially at the edges and insulated by suitable procedures with long life heat resistant insulating coat.

Both sides of each sheet shall be insulated with a durable, heat resistant insulation. The cores shall be held firmly by core clamp and brace to ensure adequate mechanical strength to support the winding and to withstand without damage or deformation, the forces, caused by short circuit stresses, transportation or handling to prevent shifting of the core laminations.

The core shall be solidly grounded to the tank and shall be provided with approved lifting devices or lifting lugs at suitable points of the core assembly for core lifting.

EW-2.4.7.4.3 Windings

Windings for transformer shall be of the best modern design of conductor having constant cross-section and uniform insulation or graded insulation as required. The coils shall be wound and supported in a manner to provide sufficient oil ducts which will be maintained without constriction.

End coils shall have extra insulation. Coils shall be made up, shaped and braced to provide for expansion and contraction due to temperature changes in order to avoid abrasion of insulation and provide rigidity to resist movement and distortion caused by abnormal operating conditions.

Adequate barriers shall be provided between windings and core and between high and low voltage windings. End coils shall have extra protection against abnormal line disturbances. Permanent current-carrying joint for splices shall be welded or brazed, properly formed and finished, and insulated to conform to the basic insulation.

Winding conductor shall be free from scars, burrs and splinters and shall be uniformly insulated.

The completed assembly of core and coils shall be vacuum dried, immediately impregnated and immersed in dry oil. They shall be adequately braced to withstand ocean shipment, short-circuit forces and earthquakes.

EW-2.4.7.4.4 Bushing

All porcelains used in bushing shall be wet process, homogenous, and free from cavities or other flaws. The glazing shall be uniform in color and free from blisters, burrs and other defects. All porcelain parts shall be one piece. The bushings of the same rating shall be interchangeable.
Bushing up to 110 kV BIL shall be porcelain bulk type whereas bushings above 110 kV BIL shall be condenser-type. In the latter case, the bushing shall be provided with capacitance test tap.

Bushings shall have the continuous current-carrying capacity necessary to carry the full 65^{0}C temperature rise. The bushings shall also be capable of carrying overload currents as required by EW-2.4.7.3.4

The terminal pads shall be of high conductivity bronze or copper and shall be plated with hot flowed electro silver or electro-tin. Whenever a larger terminal

pad is required for higher current rating, the mounting holes shall conform to NEMA Standards.

The HV and LV terminations of the ESS transformer shall be fitted with suitable insulating shroud. The insulating shrouds shall be manufactured through dip moulding process and shall be made from flexible polyvinyl chloride (PVC) material, suitable for low voltage to high voltage applications. The insulating shroud shall be flame retardant, conforming with the UL 94 Standards. They shall be type tested for electric strength in accordance with IEC 60243-1 or approved equivalent standards.

EW-2.4.7.4.5 Gasket

Gaskets shall be unaffected by hot insulating oil, retain their resiliency during the life of the associated equipment, and be unaffected by weather while maintaining oil and gas tightness. Nitrile rubber gaskets are acceptable. Gaskets of neoprene and/or any kind of impregnated/bonded cork or cork only are not acceptable. Gasket flanges shall have grooves or metal stops to prevent over compression of gaskets. All bolted transformer tank or accessory openings shall be gasketed.

EW-2.4.7.4.6 Tank

The transformers shall be housed in a steel tank with all permanent joints molded, backed up by a sturdy steel structure as required to obtain the desired rigidity and strength. The material shall be of high grade steel plate having good welding qualities. All seams, flanges, lifting and jacking lugs, braces and other parts attached to the tank shall be welded. No rivets shall be used. The cover shall be bolted type. The tank shall be able to withstand an internal pressure with oil at operating level.

All openings such as joint between the case and cover, bushings insulation mountings, etc., shall have welded on flanges to provide gaskets surfaces and allow for bolt holes. No bolts shall pass to the inside of the case and cover. Flanges shall have gaskets which will remain oil-tight and will not deteriorate under severe conditions. The tank with radiator fitted shall be tested for leaks before painting.

EW-2.4.7.4.7 Radiators

Radiators, if to be provided, shall be bolted to the main transformer tank and readily detachable. Isolation valves shall be fitted to the tank to permit radiator removal without draining the main tank. Separate filling plugs, air bleed plugs and drain plugs shall be fitted to each radiator section. Radiators shall be galvanized externally prior to etching and painting. Particular attention shall be given to their internal cleaning and painting to ensure that the radiators arrive in a serviceable condition. All radiators shall be completely sealed with blanking plates and neoprene seals for transport. They shall be thoroughly dried before shipment.

EW-2.4.7.4.8 Hardware

All energized hardware, i.e., bolts, nuts and washers shall be made of tinned copper alloy material such as silicon bronze or equivalent. All other hardware shall be hot-dip galvanized.

EW-2.4.7.5 Fittings and Accessories

The following transformer accessories shall be included:

a) HV Bushing
b) Oil Level Indicator
c) Oil Sampling Plug
d) Oil Drain Valve
e) Oil Temperature Indicator
f) Pressure Relief Valve
g) Lifting Lugs
h) Anchor Bolts
i) Earthing Terminals
j) HV/LV Insulating Shroud

EW-2.4.7.6 Equipment and Marking

The transformer shall be provided with a stainless steel nameplate in accordance with the latest standard of IEC60076-1, fitted in a visible position showing the information indicated below. The entries on the plate shall be indelibly marked.

a) Kind of transformer
b) Number of this standard
c) Manufacturer's name
d) Manufacturer's serial number
e) Year of manufacture
f) Number of phases
g) Rated power (in kVA or MVA)
h) Rated frequency (in Hz)
i) Rated voltages (in V or kV) and tapping range
j) Rated currents (in A or kA)
k) Connection symbol
l) Short circuit impedance (in %Z)
m) Type of cooling (i.e., OA, ONAN, etc.)
n) Insulation voltage (withstand voltages)
o) Insulating liquid
p) Temperature rise (in °C)
q) Total mass, kg
r) Mass of insulating oil

The minimum recommended dielectric strength of oil filling the transformer shall also be engraved on this plate. The rating plate and any other instructions or designations shall be in the English language.

EW-2.4.7.7 Standard and Common Tools

The Manufacturer of transformer shall provide standard/common tools for use in the installation/maintenance of transformer.

EW-2.4.7.8 Tests

All tests shall be performed as per latest revision of ANSI C57.12.90 Factory Test shall include, but not limited to the following:

EW-2.4.7.8.1 Routine Test

1. Ratio, Polarity and Phase Relation Test
2. No Load Losses and Excitation Current at rated Voltage and Frequency
3. Induced Potential Test (Low-frequency Dielectric Test)
4. Mechanical (Leak Test)

EW-2.4.7.8.2 Design Test

1. Winding Resistance Measurement Test
2. Impedance Voltage and Load Loss Measurement
3. Temperature Rise
4. Lightning Impulse
5. Audible Sound Level
6. Mechanical (Lifting & Moving Devices, Pressure Test)

EW-2.4.7.8.3 Miscellaneous Test

1. Insulation Power Factor
2. Insulation Resistance
3. Short Circuit Capability

EW-2.4.7.8.4 Site Test

The Supplier shall perform all tests specified by the equipment Manufacturer, applicable standards and as necessary to verify the proper operation of the equipment in the presence of NPC representatives.

1. Check level and alignment of the installed transformer;
2. Check tightness of connections and fastenings;
3. Check proper grounding;
4. Check oil level monitors, nameplate, vent plugs;
5. Check wire and cable connections;
6. Check cable glands and entrance; and
7. Check on the proper installation of transformer accessories.
8. Winding resistance
9. Insulation Resistance
10. Transformer Turns Ratio
11. Dielectric Test
12. Insulation Power Factor or Dissipation Factor

EW-2.4.7.9 Failure to Meet Guarantees

Depending on the requirement stated in the Technical Data Sheets, the transformer will be tested for compliance with the Manufacturer's guaranteed losses. If the transformer losses, as determined by test, at rated voltage, frequency and 100% rated kVA exceed the guaranteed total losses, the excess in losses shall be evaluated at the following rated cost and the resulting amount shall be deducted from the contract price.

$$S = 2\,[(N_{L\text{-}L})\,(N_{LM} - N_{LG}) + (L_L)\,(L_{LM} - L_{LG})]$$

Where:

S	=	Amount to be deducted from the Contract Price
$N_{L\text{-}L}$	=	Price in Php/Watt for the no-load losses as stated in the Technical Data Sheets
N_{LM}	=	Measured no-load losses expressed in Watt
N_{LG}	=	Guaranteed no-load losses as stated on the Technical Data Sheets
L_L	=	Price in Php/Watt for the load losses as stated in the Technical Data Sheets
L_{LM}	=	Measured load losses expressed in Watt
L_{LG}	=	Guaranteed load losses as stated on the Technical Data Sheets

When the excess of the total losses reaches five percent (5%), NPC shall have the right to reject the transformer for which such excess is verified during the factory acceptance test.

Successful Bidder shall promptly provide NPC one (1) original and three (3) certified copies of all test data and reports on the transformer.

EW-2.4.7.10 Data and Documentation Requirements

The following documents shall be submitted after award of contract for NPC's review and approval prior to procurement and installation of the supplied equipment and materials:

1. Outline drawings of transformer and accessories showing the following:
   a) General Dimensional Drawing
   b) Sectional Drawing
   c) Nameplate Drawing
   d) Marshaling box with connection diagram
2. Description and instructions covering the installation, operation and maintenance of the transformer and accessories;
3. Duly signed Routine Test Results; and

4. Field Test to be Performed and Certified Test and Inspection Reports duly signed and witnessed by NPC representative

EW-2.5 Warranty

The ESS including but not limited to the Battery Management System, Battery Modules/Batteries, Power Conversion System(s)/Battery Inverter, ESS Control System/ESS controller, and ESS transformer shall have a minimum warranty of five (5) years. This warranty shall be covered by a back-to-back warranty arrangement with the manufacturer. The supplier shall submit its warranty agreement with the manufacturer that stipulates the scope and responsibilities of each party. Both parties (bidder and manufacturer) shall be equally and severally liable for failure of either party to perform warranty obligations.

Batteries shall be tested at least once a year (or as the need arises) to ascertain the usable energy of the ESS within the warranty period. If at any time during the warranty period the ESS fails to deliver the required usable energy, the supplier/manufacturer shall repair or replace the defective components to ensure the required performance standards are met. All costs associated with the warranty shall be to the account of the supplier/ manufacturer.

EW-2.6 Track Record

EW-2.6.1 ESS Manufacturer

Manufacturer of the ESS should have current (working) install base of more than 1MW. Bidder shall provide a list of reference project(s) with contact details for verification purposes. (fill-out form in Section VI – Technical Specifications – Part II Technical Data Sheet – Annex D).

EW-2.6.2 Battery Manufacturer

Manufacturer of the batteries should be ISO 9001/14001 certified and have at least five years of experience in production of Li-ion cells as given by EW-2.4.2 (c). Offered battery model must have a current (working) install base of at least 1MWh. Bidder shall provide a list of reference project(s) with contact details for verification purposes. (fill-out form in Section VI – Technical Specifications – Part II Technical Data Sheet – Annex E)

EW-2.7 Measurement of Payment

Measurement of payment for all electrical works shall be based on the bid price of each item as shown in the Schedule of Requirements – Electrical Works, Section VII of the Bid Document. The cost of each item shall cover all works required and described in the pertinent provisions of the specifications.

SECTION VI

PART I-TECHNICAL SPECIFICATIONS

ELECTRICAL WORKS

EW 3.0 – POWER AND ENERGY MANAGEMENT SYSTEM

PART I – TECHNICAL SPECIFICATIONS

EW – ELECTRICAL WORKS

EW – 3.0 – POWER AND ENERGY MANAGEMENT SYSTEM

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PART I – TECHNICAL SPECIFICATIONS

EW – ELECTRICAL WORKS

EW-3.0 POWER AND ENERGY MANAGEMENT SYSTEM

EW-3.1 General

This part specifies the minimum requirements for the design, manufacture, factory wiring, programming, transport, delivery, installation, testing and commissioning of the Power and Energy Management System (PEMS). It shall be able to monitor, supervise and control the gensets, solar PV plant, ESS and plant auxiliaries/instrumentation. All materials and parts which are not specifically mentioned herein but are necessary for the proper installation, assembly and operation of the equipment shall be furnished at no additional cost to NPC.

The Supplier shall have the complete system responsibility for the proper design and functioning of the system from manufacture until system acceptance. All the system engineering software and on-line system shall be supplied whether specifically detailed herein or not. It is not NPC's intent to specify all the technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. Adherence to all applicable codes and standards is required. The Supplier shall furnish high quality equipment meeting the requirements of this specification and industry standards.

The system shall provide reliable and timely information data and control functions required for efficient operation of the hybrid power plant. The required system shall have the operational speed, computing power, adequate input/output storage capacity and self-diagnostic/analysis capability to meet the requirements as detailed in this specification.

EW-3.2 Technical Requirements

The PEMS covered by this specification shall include all equipment including software necessary for secure and reliable operation of the whole system. The system shall consider provisions for future expansion of the plant capacity.

The proposed PEMS shall be composed of but not limited to the following subsystems:

a) **Hybrid Controller** is the main controller and shall communicate and interface with the other controllers.

b) **Genset Controller** is an automatic controller that has all necessary functions for control and protection of generator sets.

c) **Solar/PV Controller** controls and manages the output and operation of Solar/PV inverters.

d) **ESS Control System (ECS) / ESS controller** supervises the operation of the Battery Management System (BMS) and Power Conversion System (PCS).

e) **Data Logger** is primarily for the purpose of storing data of the entire grid's operation and maintenance, especially of the string inverter(s) through Solar/PV Controller.

Design Requirements

1. The PEMS shall be an automated/programmable Hybrid Plant Management System with pre-configured settings for hybrid system. It shall not require specialized programming knowledge or skills to set or modify desired operating conditions. It shall be composed of a hybrid controller, genset controller(s), solar/PV controller, and energy storage system controller.

2. The hybrid controller installed inside the Diesel Power Plant Control Room shall interface and communicate with the genset controller(s), solar/PV controller and the ESS controller. The Hybrid controller shall communicate with and store data in the Data Logger. The Hybrid controller shall allow remote accessing of the data stored in the data logger thru the Human Machine Interface (HMI).

3. The PEMS shall be responsible for the dispatch of the Solar PV Plant, Diesel Generators and the ESS. Dispatch strategy shall maximize PV penetration. Under the condition of protecting the gensets, the available irradiation and load demand, the PEMS shall optimize the generated power of the solar plant while considering the constraints (e.g., individual minimum genset loading, genset availability, SoC of the ESS) and shall regulate and stabilize the grid by dispatching the ESS and/or available compatible genset.

4. PEMS shall have the capability to export operating data, including faults and other abnormal conditions to an external media for review and archive purposes.

5. The PEMS shall perform the following functionalities but not limited to the list below:

   a) Scheduling and Dispatching
   b) Start/stop of Diesel Generator(s) and ESS
   c) Engine Ramp Up/Down Control
   d) Generator Breaker Open/Close Control
   e) Diesel Generator Parallel Operation/Synchronization
   f) Visual and Audible Alarm System
   g) Control of Solar Photovoltaic Array/Inverters
   h) High level control of ESS functions (i.e., charging, discharging)
   i) Automatic Fail over Features/ System Redundancy.
   j) Data Logging / Event Recording
   k) Load Balancing and Distribution
   l) Database Management
   m) Metering Instrument
   n) Voltage and Frequency Regulation

6. The PEMS shall also have the capability to display and store the following information in real time or other user configurable time periods:

   a) Total system demand in kW & in kVAr
   b) Energy output in kWh
   c) System voltage, frequency, and power factor.
   d) Power/Energy output and operating status of all generating units including the Solar PV Array and the ESS in kW and kWh
   e) Alarms for faults and other abnormal operating conditions for the Generator sets, Solar PV plant and ESS for Generating units, ESS and Solar PV plant.

7. The PEMS shall be able to monitor the entire grid through the HMI. For the manual control mode of the plant, a control panel shall be provided. The panel shall be capable of start and stop sequence and emergency shut down. Further, in certain case, hardwired controls are provided to ensure grid safety and/or operability in the event of PEMS failure.

8. The Supplier shall be responsible for preparation of programs and turning over the complete operational system to NPC. The Supplier's configuration responsibilities shall include, but not limited to the following functions: all plant control system functions, equipment safety, protection, man-machine interface functions, operator training for setting parameters and overall system configuration and testing. Configuration of settings for each and between functional controllers shall be made and tested by the Supplier/Manufacturer at their facilities. Any modification(s) done by the Supplier to the system default settings of the new controller(s) shall inform NPC in writing.

9. The system shall be designed to monitor and diagnose its own performance. The PEMS shall prompt alerts to notify the operator of any equipment and/or sub-systems with abnormalities/errors. The monitoring and diagnostic functionality shall cover, but not limited to the following peripheral failure, I/O failure, peripheral memory error, main memory error, CPU failure, scan overruns, controller errors, loss of communication.

10. The Supplier shall provide all hardware and cabling necessary to provide redundant, fail-safe communications between the subsystems of the PEMS. Failure of any component in the system shall not cause loss of control of more than one component in the system and must not cause a total system failure.

EW-3.3 Calutcot Diesel Power Plant Genset Controller Data

Unit / Rated Capacity	Make and Model	Remarks
Unit 1 / 50kW	-	On-going Installation
Unit 2 / 50kW	-	On-going Installation

EW-3.4 Scope of Works

a) The supplier shall provide **at least two (2) units of genset controllers, one (1) unit ESS controller, one (1) unit Solar/PV controller and one (1) hybrid controller**[1]. The supplied controllers shall be brand new and able to interface with each other. **The genset controllers shall be of the same brand/manufacturer and model.**

b) The communication interface and protocol within the **PEMS (Hybrid, ESS, Genset and Solar/PV Controllers)** shall be well-established depending on the preference of the Supplier/Manufacturer to function as designed ensuring proper connectivity and reliable transfer of data/information (i.e., command, alarm, status, etc.). The connection between these controllers shall not cause any malfunction for the safe and continuous operation of the power plant. The same shall apply for the communication between **the ECS/ESS controller and the ESS (PEMS and BMS).**

c) The communication interface and protocol between **the existing genset controller and the supplied genset controller** shall be well-established depending on the preference of the Supplier. However, the Supplier shall ensure that the connection provides reliable transfer of information (data, command, etc.) and that the connection between these controllers shall not cause any malfunction to the safe operation of the gensets. The use of appropriate converters and/or relays is allowed between these devices if necessary.

d) The communication interface and protocol between each **inverter and the Solar/PV controller** shall utilize Modbus TCP. The use of alternative communication protocols with appropriate converters and/or gateways may be allowed subject to the approval of NPC. Necessary converters and/or gateway devices shall be supplied to ensure safe and reliable transfer of information.

e) The supplier shall provide all necessary converters and other appurtenances and accessories to ensure the reliability of the communication between these devices and components. The supplier shall ensure that the converters shall not cause any lag time when transforming the signals given to and from the equipment. **Refer to figure 1 in this section.**

f) The communication link between the Solar PV Plant and the PEMS shall utilize **copper wires used to transfer data only.** Refer to EW-3.5 Communication Interface and Monitoring System, Item c) Communication Cable for specifications.

g) The PEMS shall have control and remote monitoring functionalities that is accessible locally (within the power plant) and remotely through computer or mobile phones (via internet/GPRS).

h) The PEMS shall be modular, expandable, and flexible to accommodate potential expansion of ESS, additional PV arrays (inverters) and additional gensets without the need of special programming skills.

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[1] The Supplier may opt not to furnish Hybrid Controller when using CAN communication protocol between PEMS controllers (multi-master structure).

These additional components for future expansion purposes projects can be from different manufacturers and can have different brands and models compared to the existing NPC components and the selected components of the Supplier. The PEMS shall be able to reliably communicate to such independent components.

i) Supplier shall provide all necessary cables, connectors, interfaces, software, licenses and other equipment and devices to ensure interoperability of all components of the entire power plant.

j) The supplier, with minimum configuration as possible, shall install and integrate the supplied controllers to the existing controls of gensets to take-over the following functionalities, except that the protection system shall remain and under the supervision of existing genset controller(s):

1. Start and Stop of Genset
2. Engine Ramp Up/Down Control
3. Generator Breaker Open/Close Control
4. Synchronization

If major configuration is unavoidable to ensure the performance of the required functionalities and may potentially void the existing warranty, the supplier shall submit an explanation of the reasons and ramification of the change to NPC for approval/consideration.

In the case that the genset(s) is/are no longer covered by any kind of warranty, the replacement of the existing controller(s) by the new controller(s) maybe permitted provided that it will not degrade the performance and cause any malfunction to the equipment. The Supplier shall seek clearance in writing to NPC prior to taking any action for this specific work item.

Notwithstanding the above, the supplier shall ensure that any changes will not affect the proper operation of the gensets.

k) The supplier shall include in the training the integration and installation including trouble shooting of all the controllers associated to PEMS.

l) The supplier shall provide two (2) complete units/sets of Human Machine Interface (HMI) of the same brand and model. One (1) unit/set shall be installed inside the ESS and the other unit/set inside the control room.

m) The HMI shall have adequate security features to prevent accidental and unauthorized modification of operating parameters.

n) Bidder shall inspect the existing power plant to determine the full extent of the project. Integration methodology shall be submitted together with the proposal(s) for approval of NPC during contract implementation.

o) All other works necessary but not specifically mentioned and detailed in the scope of works shall be done for the complete, safe, and reliable operation of the Power and Energy Management System (PEMS).

p) The controllers to be used in PEMS shall have a track record that indicates the exact make and model being offered are used for at least three (3) Hybrid Systems that are currently working and are in actual

operation (fill-out form in Section VI – Technical Specifications – Part II Technical Data Sheet – Annex F).

EW-3.5 Communication Interface and Monitoring System

a) Communication Interface

1. The communication link shall be able to support real time data logging, event logging, supervisory control, operational modes and set point editing.

2. It shall have appropriate communication interfaces to be provided by the Supplier between various units installed at different locations that report data for power generated on demand with options for hourly, daily, monthly, and yearly data.

3. The appropriate communication interface to be installed in the solar PV plant shall be properly connected. Also, the appropriate communication interface for the PEMS/PV Controller shall be installed at the DPP Control Room. These interfaces together with their auxiliaries and the communication cable shall provide reliable two-way communication between the inverters and the Solar/PV controller or the PEMS.

4. The communication link between the SPP/PV Controller and PEMS shall be robust technology over a copper wire dedicated for two-way data communication only.

b) Control System

1. The Solar PV Plant shall be designed as grid-interactive system with line protection and fail-safe system. It shall be equipped with all necessary instrumentation to provide adequate monitoring and control of the system under all operating conditions.

2. The Supplier shall provide Solar PV Plant monitoring system. The monitoring system shall have a data logging capability to record major operating parameter (i.e., kW, kWh, V, A, pf, frequency, etc.)

c) Communication Cables

1. Control cables of adequate size, impedance and insulation shall be required for establishing communication and control between equipment.

2. All communication cables shall be marked accordingly, or color coded depending on application and/or connection.

3. Connection of cables shall follow the standard/acceptable colors for the ease of installation and maintenance purposes. Ethernet cables shall follow the color coding for connections as well as other communication cables, as applicable.

4. All cables, in general, shall conform to IS-1554 part 1; ISO/IEC 11801 and other relevant standards.

5. The control cables shall be appropriate for its intended fields of application ensuring maximum performance and of the following specifications but not limited to the following:

   a. RS-485 cables shall be heavy duty or for industrial use, stranded copper conductor, polyethylene insulated with a minimum of 90% shielding coverage of braid or a combination of braid-foil shielding materials for maximum performance. Likewise, it shall be Flame Retardant Low Smoke (FRLS) PVS type jacketed. It shall be multi-conductor, multi-pair with low capacitance.

   b. Ethernet cables shall be capable to support different applications. Its construction shall be multi-conductor, multi-pair shielded twisted pairs of stranded copper conductors with polyethylene insulation. The outer jacket material shall be flame retardant PVC material.

d) Data Monitoring

1. The data monitoring system shall include both Data Management Monitoring System and Weather Observation System which shall have one-collecting device with a display monitor which is capable of monitoring and controlling the solar farm parameters such as PV array energy production, actual AC/DC voltages and currents at inputs and outputs of the inverters, daily and accumulated energy generated, climate conditions and faults in the SPV system, at solar plant site.

2. The system shall also have the capability for calculating the average of the data collected every hour, day and month.

3. Following parameters shall be measured and stored continuously:

   - Solar module temperature/s
   - Ambient temperature
   - Solar irradiation/insolation
   - Wind speed
   - DC current and voltages
   - Power output of the solar arrays
   - Power output of gensets
   - Power plant load
   - User selectable time period of cumulative energy production for PV array
   - System faults
   - Any other parameter considered necessary for the SPV system based on prudent practice

4. For solar irradiance monitoring, Class I or better integrating pyranometer shall be provided, with the sensor mounted in the plane of the SPV array.

5. Data Logger shall record these parameters for study of various environmental and grid parameters on energy generated by the solar PV system.

EW-3.6 PEMS and Communication Architectural Diagram

The PEMS and Communication architecture shall be as presented below. However, the Supplier may offer similar or equivalent system architecture subject to NPC's review and approval.

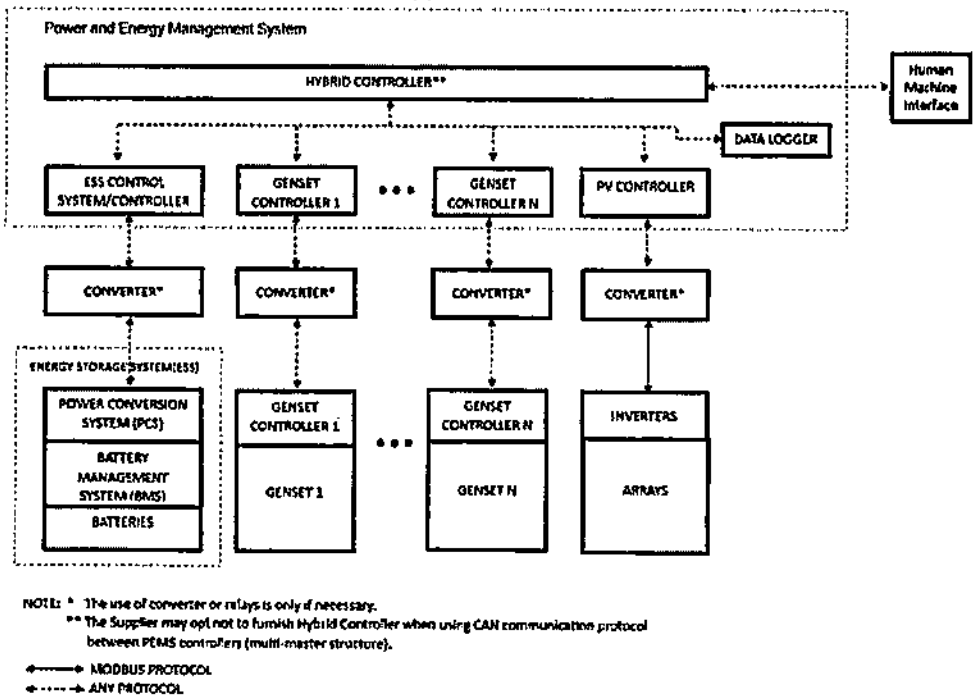

Figure 1: PEMS and Communication Diagram

EW-3.7 Warranty

The PEMS, including all its components, shall have a minimum warranty of five (5) years. This warranty shall be covered by a back-to-back warranty arrangement with the manufacturer. The supplier shall submit its warranty agreement with the manufacturer that stipulates the scope and responsibilities of each party. Both parties (bidder and manufacturer) shall be equally and severally liable for the failure of either party to perform warranty obligations.

EW-3.8 Measurement of Payment

Measurement of payment for all electrical works shall be based on the bid price of each item as shown in the Schedule of Requirements – Electrical Works, Section VII of the Bid Document. The cost of each item shall cover all works required and described in the pertinent provisions of the specifications.

SECTION VI

PART I-TECHNICAL SPECIFICATIONS

ELECTRICAL WORKS

EW 4.0 – GROUNDING SYSTEM

PART I – TECHNICAL SPECIFICATION

EW – ELECTRICAL WORKS

EW – 4.0 – GROUNDING SYSTEM

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PART I – TECHNICAL SPECIFICATIONS

EW – ELECTRICAL WORKS

EW-4.0 GROUNDING SYSTEM

EW-4.1 General

This specification covers the technical and associated requirements for the entire grounding system of the Solar PV Plant, required to protect people and equipment, to reduce electromagnetic interference (EMI) and to allow safe service and maintenance of the installations. The grounding system includes all major and minor equipment such as PV modules, mounting structures, inverters, AC box, DC boxes, transformer and protection panel, ground rods, etc. and connections.

All materials and parts which are not specifically mentioned herein but are necessary for the safety of operating personnel and safe operation of the plant shall be furnished and determined by the Supplier at no additional cost to NPC.

EW-4.1.1 Technical Characteristics and Requirements

The ruling criteria in the design of the grounding grid shall be the safety of personnel and the proper operation of the electrical equipment during normal operation and during transient disturbances such as short circuits in the electric power system and during lightning discharges. The grounding system shall meet the following minimum requirements:

ITEM	DESCRIPTION	REQUIREMENTS
Grounding Design Criteria		
1	Fault duration, sec.	3
2	Total fault level (line to ground), kA	8
3	Grounding connection (exothermic, compression, etc.)	Exothermic
4	Grid conductor (specify size and type)	$\geq$ 100 mm^2 stranded copper conductor (bare)
5	Bonding Conductor (riser)	
	a. All major equipment such as inverter, transformer, ESS, etc.	$\geq$ 100 mm^2 stranded copper conductor with 1.2 kV PVC Insulation
	b. For motors/pumps rated 30kW and above, CT/PT, FDS, LA, etc.	$\geq$ 50 mm^2 stranded copper conductor with 1.2 kV PVC Insulation
	c. For motors/pumps rated below 10kW, perimeter lighting and fence earthing	$\geq$ 22 mm^2 stranded copper conductor with 1.2 kV PVC Insulation

6	Burial depth of grid conductor below finished grade, m	0.6
7	Ground mat design resistance	5 Ohms (max.)
8	Permissible temperature rise of grid copper conductor, ^{o}C	300
9	Ground Rod	
	a. Type	Copper rod
	b. Diameter, mm	≥ 19 mm
	c. Length/section, m	≥ 3 m
10	Resistivity of crushed rock, (wet) Ohmmeter	3000
11	Approximate area of plant/switchyard to be covered by the ground grid	Refer to Bid Drawings
12	Soil resistivity (for calculation), ohmmeter	By Supplier[1]
Lightning Protection		
1	Manufacturer	By Supplier
2	Place of Manufacture	By Supplier
Lightning Rod		
1	Material	Copper
2	Length, mm	2000
3	Minimum Diameter, mm	16
Down Conductor		
1	Type	Insulated Copper Conductor
2	Minimum Cross-Section Area	50 mm^2
3	Overall Diameter, mm	By Supplier

The Supplier shall carry out earth resistivity measurement for the plant site. Based on the result of this measurement and the system parameter, the appropriate design and the calculation will be determined whether impermissible touch and step voltages occur at any place inside plant area and at any place 10 m outside of the plant boundary line which may be endangered. These calculations will decide on the provisions for grounding to be made with the relevant part of the civil works related to foundations. If the calculations proved after the application of all engineering possibility that touch and step voltages are still higher than permitted and consequently the Supplier managed to design the earthing and grounding grid in such a way to obtain the lowest touch and step voltage value, all documents including limitation and justification shall be provided to NPC for approval.

If in case the actual measured resistance of the Supplier-designed and installed ground grid is higher than specified in this section, the Supplier shall install, at no extra cost to the NPC, additional grounding rods, mats, grounding

[1] Design of grounding system is responsibility of Supplier including measurement of actual soil resistivity.

electrodes, etc., until the field-measured resistance is equal to or less than the specified value.

The ground grid shall be composed of a system of copper conductors buried approximately 60 cm. beneath the surface of the earth, excluding crushed rock surfacing. Driven ground rods shall be installed at regular intervals and connected to the grounding conductor at grid nodes. A minimum of four (4) of the specified ground rods must be installed (one at each corner of the ground grid). The Supplier shall determine the spacing of ground grid conductors and the total number and location of ground rods and their lengths (single or two or more coupled sections).

EW-4.1.2 Lightning Rod and Support

The lightning rod shall be copper-covered steel of circular cross section, with a nominal diameter of 16 mm and a nominal length of 2 meters.

The air terminal (lightning rod) shall be located at the highest point of the facility to capture the lightning strike to a preferred point, so that the discharge current can be safely directed via the down conductor to the grounding system. The lightning rod support shall consist of a minimum of 3.0 meters of galvanized iron piping mast. The Supplier shall give technical details of the protection including mounting and installation details for approval.

EW-4.1.3 Lightning Down Conductor

The down conductor will provide a low impedance path from the air termination to the ground system so that the lightning current can be safely conducted to earth, without the development of excessively large voltages.

The lightning down conductor shall be made of electrical grade copper, with a minimum cross-sectional equivalent to 55 mm^2. The conductor shall consist of helically copper strands bound by a semiconductor cross-linked polyethylene and an outer PVC jacket.

In order to reduce the possibility of dangerous sparking (side-flashing), the down conductor route(s) should be as direct as possible with no sharp bends or stress points where the inductance, and hence impedance, is increased under impulse conditions. The down conductor should not be subject to bends of less than 0.5-meter radius and shall be secured to the structure by approved metallic fastening at least every 2.0 meters.

EW-4.1.4 Grounding Cables

Grounding cables shall be copper conductor of soft drawn or hard drawn concentric stranding bare copper conductor in accordance with the latest revision of ASTM B3 and manufactured in accordance with ASTM Specification B8 (class B).

EW-4.1.5 Ground Rods

The ground rod shall be copper-covered steel of circular cross section, with a nominal diameter of 19 mm and a nominal length of 3 meters.

Each ground rod shall have a conical swaged point at one end and shall have a continuous smooth copper covering of at least 0.254 mm thickness molten-welded or copper bonded (electro-deposit) to a steel core. The copper clad or pressed type will not be accepted.

EW-4.1.6 Exothermic Welding Materials

The Supplier shall supply exothermic welding materials for cable-to-cable, cable-to-ground rod and cable-to-steel structure grounding connections. These materials shall be Cadweld or approved equal. The Supplier should submit detailed information describing the proposed process.

EW-4.1.7 Grounding Hardware

Terminal Lugs

Terminal lugs shall be one hole, socket type, rounded edge lug, cast of high strength corrosion resistant copper alloy. Machine screws, nuts, and washers used with the lugs shall be bronze.

EW-4.1.8 Steel Structure Grounding

All generating plant metal parts such as structures, equipment, cable trays, fence, etc. shall be connected to the ground grid by suitable ground connections.

If there is any possibility for a conductor to fall down on a steel structure, this structure must be connected to the grid with a connection able to sustain the earth fault current.

EW-4.1.9 Equipment Earthing

Transformer Earthing

The transformer shall be earthed at two points diagonally opposite each other. These connections shall be made from two different points of the earthing grid.

Lightning Arrester

Lightning arresters shall be connected to the earthing grid with 50 mm^2 stranded copper conductor with 1.2kV PVC Insulation.

Power Cables

The lead sheath or armor (shield) of the MV power cables, if to be provided, shall be earthed by connecting a flexible braid to the shield. This shall be done at both ends of each cable. Cable end boxes shall be earthed with copper cable connection on one of the mounting bolts.

Lighting Poles

Poles for lighting shall be connected to the earthing grid with 22 mm^2 stranded copper conductor with 1.2kV PVC Insulation (one connection for each pole).

Other Metallic Structures

Other types of metal structures within the diesel / solar PV plant area, not mentioned thereto, shall be connected to the earthing grid.

Major equipment shall be equipped with at least two (2) terminals or suitable grounding pads of adequate size to accommodate at least two fixing screws for proper connection to the earthing system.

EW-4.1.10 Building Earthing

Generally, each electrical device inside the control building/room must be equipped with an earthing screw of sufficient diameter for connection to the earthing system. The same applies to all metallic parts such as panels, etc. which are effectively connected by earth conductors.

Control panels and desks, switchboards, etc. consisting of several individual sections or compartments shall each be connected to a common tinned copper earth bar unless all panels are solidly welded together, or other approved means are applied ensuring solid earthing connections. In such a case, provisions for earthing must be made at one end at least.

EW-4.1.11 Fence Earthing

Steel fences around the switchyard or station shall be connected to the earthing system at appropriate connection point along the fence and at all corners and gate posts.

EW-4.1.12 Pipe Earthing

All piping shall be earthed at all service points in an approved manner.

The conceptual design of the grounding system based on the specified conditions shall be referred to the bid drawing.

The supply shall include special tools, kits and expandable materials necessary to weld the grid joints and ground rod connections by exothermic process, including reasonable waste to be expected during installations. Standard grounding connectors shall be fixed to metal frames by means of bolted clamps.

EW-4.1.13 Cable Tray Earthing

Cable trays and ladders shall be connected to the earthing system at every ten (10) meters interval.

EW-4.1.14 Ground Rods

Ground rods shall be driven to a depth such that the top of each rod is at the same elevation as the ground grid and shall be bonded to the ground grid conductors by suitable exothermic connections.

EW-4.2 Measurement of Payment

Measurement of payment for all electrical works shall be based on the bid price of each item as shown in the Schedule of Requirements – Electrical Works, Section VII of the Bid Document. The cost of each item shall cover all works required and described in the pertinent provisions of the specifications.

SECTION VI

PART I-TECHNICAL SPECIFICATIONS

ELECTRICAL WORKS

EW 5.0 – TAKE-OFF STRUCTURE ACCESSORIES AND APPURTENANCES

PART I – TECHNICAL SPECIFICATION

EW – ELECTRICAL WORKS

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PART I – TECHNICAL SPECIFICATIONS

EW – ELECTRICAL WORKS

EW-5.0 TAKE-OFF STRUCTURE ACCESSORIES AND APPURTENANCES

EW-5.1 General

This specification covers the furnishing of all labor, materials, equipment, tools and other incidentals for the installation of take – off structure accessories and appurtenances for Calutcot Island Solar PV Plant.

All equipment and materials which the Supplier shall supply and install shall be new and unused. They shall be suitable for their intended purpose complying with all applicable regulations, quality and dimension standards.

EW-5.2 Scope of Work

In accordance with the specification contained in this section and as shown on the bid drawings, the works and services to be performed by the successful bidder shall essentially consist of but not limited to the following:

a) Supply, installation and test of medium voltage power cables and conduit complete with appurtenances and accessories;

b) Supply, Installation and Test of 15kV Fuse Disconnect Switches with Lightning Arrester Combination;

c) Supply, Installation and Test of Grounding System;

d) Supply, Installation and Test of Lightning Protection System;

e) All other works and services including those not specifically detailed herein but are required for the complete, safe and reliable operation of the project.

The Supplier shall perform the entire quantity of work necessary to complete the installation of the take-off structure accessories and appurtenances at the Contract Unit Price, be it more or less than the quantity herein estimated.

It is not NPC's intent to specify all technical requirements nor to set forth those requirements adequately covered by applicable codes and standards. The Supplier shall furnish high quality equipment meeting the requirements of the specification and industry standards.

EW-5.3 Codes and Standards

All equipment covered by this specification shall be designed, manufactured, assembled and tested in accordance with, but not limited to, the latest issues of applicable ASTM, AWS, AZI, ASCE, ISO or equivalent standards, including all addenda, in effect at time or purchase order unless otherwise stated in this specification.

EW-5.4 Power, Control and Instrumentation Cable

This specification covers the technical and associated requirements of power, control and instrumentation cables, and medium voltage power cable for use in switchyards.

All cables shall be designed to withstand the short-circuit condition and voltage drop of 3% (max.).

EW-5.4.1 Technical Characteristics and Requirements

The cables to be supplied shall have insulation levels able to withstand any voltage surges which are normally expected to occur in the power system in which the cable is to be used, due to switching operations, sudden load variations, faults, etc. The medium voltage XLPE power cable and the 600V power, control and instrumentation cable to be supplied shall be compliant to ICEA S-66-524 or IEC 60502-2 and UL 83, PNS 35, ICEA S-73-532 specification and requirements of PEC respectively.

The cables shall be selected to withstand without distress any short-circuit currents in the conductor and sheath related to the existing fault levels.

The cables and its accessories shall be manufactured to fulfill the requirements when operating with full load or at any load factor.

The power cables shall meet the following minimum requirements:

ITEM	DESCRIPTION	REQUIREMENTS
1	Conductor Shape	Circular Stranded Wire
2	Conductor Material	Annealed Copper
3	Insulation	
	a. Material	Cross-linked polyethylene (XLPE)
	b. Thickness, mm	≥ 4.5
4	Outer covering/Jacket	
	a. Material	PVC Sheath Jacketing
	b. Thickness, mm	Manufacturer's Data
	c. Termite Protection Required	Yes
5	Shielded	Yes
	a. Type of Shielding	Copper Tape Screen
6	Provided with Filler and Binder Tape	Yes

EW-5.4.2 Insulation

Insulation shall be of the type specified in the Technical Data Sheets.

EW-5.4.3 Jacket

A tough, ozone, low chlorine, heat, flame and moisture-resistant PVC or Nylon jacket capable of providing protection against sunlight, acids, alkalis and oils shall be furnished for all cables.

EW-5.4.4 Assembly

All multi-conductor cables shall be bundled together with non-hygroscopic fillers to assure a smooth circular assembly. A lapped core binding tape shall be applied over the assembly.

EW-5.4.5 Application

All cables shall be suitable for installation in cable tray, conduit, trench, underground duct in wet and dry locations, and above ground raceway in damp and dry locations.

EW-5.5 Fuse Disconnect Switch with Lightning Arrester Combination

This specification covers the supply and delivery of fuse disconnect switch with lightning arrester combination for use in various diesel and solar power plants.

The materials furnished shall be in accordance with, but not limited to, the latest issues of the Applicable Codes and Standards, including all addenda, in effect at time of purchase order unless otherwise stated herein.

EW-5.5.1 Technical Characteristics and Requirements

The fuse disconnect switch to be supplied shall be suitable for high voltage transformer acting as an overload protector and a device for opening and closing the circuit. All the metal parts of the fuse disconnect switch shall be free from erosion and rust. The FDS shall meet the following minimum requirements:

ITEM	DESCRIPTION	REQUIREMENTS
1	Class (Indoor, Outdoor)	Outdoor
2	Rated voltage, kV	15
3	Nominal system voltage, kV	13.8
4	Frequency, Hz	60
5	BIL, kV	110
6	Ampere Frame	100
7	Interrupting Capacity, kA	10
8	Fuse Link	
	a. Type	Universal buttonhead design
	b. Current Rating, A	Refer to Single Line Diagram
9	Lightning Arrester	
	a. Type	Metal Oxide Varistor (MOV), gapless

	b. Class (indoor, outdoor)	Outdoor
	c. Rated frequency, Hz	60
	d. Nominal system voltage, kV	13.8
	e. Duty cycle voltage (rating), kVrms	12
	f. Maximum Continuous Operating Voltage (MCOV), for the arresters having the following duty cycle voltage, kV rms	8.4
	g. Nominal discharge current, kA	10
	h. Creepage distance, mm	465
	i. Supporting brackets, bolts, nuts, etc.	Yes

Fuse Cut-Out

Fuse cutouts shall be satisfactory use in a tropical climate with high relative humidity. The cutouts will be mounted by means of steel brackets on steel poles cross arms.

The cutouts are intended for use with buttonhead-type fuse links and must be able to accommodate fuse links meeting the interchangeability requirements of ANSI standard. The cutouts to be supplied shall include the following:

1. Fuse Support Assembly
2. Fuse Holder Assembly
3. Mounting Bracket
4. Lock Washers

Fuse Link

The fuse link to be supplied shall be universal buttonhead with tin fuse element suitable for 15 kV open type distribution cut-out to be used in the overcurrent protection of circuits. It is characterized by perfect time current characteristics, high mechanical strength and reliable arc extinguishing performance, etc. The fuse link shall meet the electrical and mechanical interchangeability requirement in accordance with ANSI standard.

Lightning Arrester

Gapless arresters shall have elements fabricated from non-linear resistance metal oxide materials to perform both the surge discharge and power frequency reseal functions.

Arresters of this type shall be protected in a hermetically sealed wet-process porcelain jacket, which shall have a high creepage distance and a high dielectric strength.

The primary terminals shall be suitable for the connection of the type and size of conductors which can be either copper or aluminum conductors without use of bimetal inserts.

The arrester shall be supplied with a cross-arm mounting bracket that conforms with the requirements of NEMA or with appropriate bracket as a cutout arrester combination on it.

All mounting bolts and conductor connection shall be provided with lock washer. Lock washers shall be fabricated from material that complies with the requirements as per ANSI standard.

All exposed steel or iron part of the arrester shall be hot-dipped galvanized in accordance with ASTM standard.

The Supplier shall submit for approval the brochures and/or catalogues with complete technical specification of the fuse cut out with lightning arrester combination including mounting brackets and accessories.

EW-5.6 Bus Conductor and Hardware

This specification covers the technical and associated requirements for stranded aluminum bus conductors and line hardware for use in various electric generating plant switchyards.

All line hardware/materials shall meet the performance requirements application criteria and manufacturing tolerances passed ANSI CB5. 1-1979 - American National Standard for Galvanized Steel Bolts and nuts for overhead line construction.

EW-5.6.1 Technical Characteristics and Requirements

Describe herein is the general specification of the bus conductor, line materials and equipment to be supplied for this project. The bus conductor, line materials and equipment shall meet the following minimum requirements:

ITEM	DESCRIPTION	REQUIREMENTS
Stranded Conductor Requirements		
1	Type designation	Aluminum Conductor Steel Reinforced (ACSR)
2	Code Name	RAVEN
3	Conductor size	1/0 AWG ACSR
4	Ampacity, A	230
5	Outer Layers	
	a. Material	Aluminum
	b. Stranding No.	6

	c. Calculated Cross-sectional Area, mm^2	53.52
	d. Coefficient of Elongation (/°C)	Manufacturer's Data
6	Core	
	a. Material	Aluminum Clad Steel
	b. Stranding No.	1
	c. Calculated Cross-sectional Area, mm^2	8.92
	d. Coefficient of Elongation (/°C)	Manufacturer's Data
7	Conductor Coefficient of Linear Expansion (/°C)	Manufacturer's Data
Conductor Hardware		
1	Tension Clamp	
	a. Type	Bolted, U-Bolt
	b. Material of Body	Aluminum Alloy
2	Connectors	
	a. Type	wedge pressure clamp for stranded conductor connection
	b. Angle and T-connectors type	wedge pressure clamp for stranded conductor connection

Stranded Conductor

All wires of the stranded conductor shall be concentrically stranded. The wires in each layer shall be evenly and closely stranded around the underlying wire(s). The tension in individual wires in a layer shall be sufficient to hold each wire firmly in place with only enough strand separation to prevent crowding at the time of stranding and during installation. All steel and aluminum wires shall lie naturally in their position in the stranded conductor and, when the core and/or the aluminum wires are cut, the wire ends shall remain in position or be readily replaced by hand and then remain approximately in position.

The aluminum shall be of the higher purity commercially obtainable which shall not be less than 99.5%. The type of conductor to be supplied shall be stated in the Technical Data Sheets and shall be manufactured according to the applicable ASTM or equivalent IEC standards.

The completed conductor shall be smooth, free from nick, burrs, aluminum or steel particles, dirt and excessive die grease. The conductor shall be absolutely free of copper dust and copper particles.

Clamps

Aluminum strain clamps and suspension clamps for aluminum conductor, if required in the Technical Data Sheets, shall have its clamp bodies and keeper pieces, made of high strength and heat treated cast aluminum alloy. Cotter bolts, U-bolts, nuts, and lock washers shall be hot dip galvanized steel. Cotter pins shall be made of stainless steel. Slip strength of the strain clamp shall be not less than 85% of the rated ultimate strength of the conductor.

Cross Arms

The cross arms to be supplied for this project shall be in accordance to ASCE manual 72 "Design of Steel Transmission Pole Structures". The materials shall meet ASTM A-570 specification (36 KSI min. steel strength) while the galvanizing shall be in accordance with ASTM A-123 specification.

Insulators

Insulators to be utilized in the project shall be in accordance to ANSI Class 55-3 for pin, Class 52-1 for suspension, Class 53-2 and Class 53-4 for spool standard as to material, ultimate tensile strength, leakage, distance, etc.

Line Hardware

Line hardware shall be made either of aluminum alloy, malleable iron or ductile iron with tensile strength in accordance with ANSI standard.

Bolts

All bolts such as carriage, double arming, oval, machine, etc. shall be hot dip galvanized as per ASTM A-153.

EW-5.7 Measurement of Payment

Measurement of payment for all electrical works shall be based on the bid price of each item as shown in the Schedule of Requirements – Electrical Works, Section VII of the Bid Document. The cost of each item shall cover all works required and described in the pertinent provisions of the specifications.

PART II – TECHNICAL DATA SHEETS

EW – ELECTRICAL WORKS

Drawings and Documents to be Submitted during the Bid

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PART II-TECHNICAL DATA SHEETS

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PART II – TECHNICAL DATA SHEETS

EW – ELECTRICAL WORKS

Documents to be Submitted during the Bid

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PART II - TECHNICAL DATA SHEETS

EW – Electrical Works

Technical Requirements

1. The Bidder is required to provide all the information required under the column "Supplier's Data". Although not given by NPC, the Supplier's Data shall be based on the International Standard.

2. NPC's requirements are indicated below. The Supplier shall indicate their data corresponding to the said NPC requirements to facilitate evaluation of Supplier's compliance to the specifications.

3. Deviation from the requirements indicated in the technical data sheets and non-submission of the required documents listed as Annexes A and B shall be ground for disqualification.

4. All data and information specified in the requirements shall be in English language.

ANNEX A - LETTER OF AUTHORIZATION AND GUARANTEE STATEMENT

The following ***Documents*** shall be submitted by the Supplier in **sequential order** as listed hereunder and shall be attached in the bid documents as **Annexes**. All data and information shall be in English language.

Letter of Authorization and Guarantee Statement for the Following Equipment:

a. Solar PV (SPV) Module
b. String Inverter
c. Energy Storage System (ESS)
d. Power and Energy Management System (PEMS) or Hybrid Controller

either from the following:

- Original Equipment Manufacturer (OEM); or
- Licensee of the OEM accompanied by a Certification from OEM as a Licensee or the Licensee Agreement; or
- Authorized Distributor (accompanied by a Certificate of Authorized Distributorship from the OEM/Licensee of the OEM. If from the Licensee, a Certification from the OEM as a Licensee or the Licensee Agreement must also be submitted).

Note: ***Documents or brochures submitted must be in English language as stated in Section II-ITB Clause 11.0.***

B-1.0 SOLAR PV PLANT

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-1.1	Total Capacity of Solar PV Plant at AC Side	At least 60 kW	
B-1.2	Total Number of Inverters connected in parallel	By Supplier	

B-2.0 SOLAR PV MODULES

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-2.1	Manufacturer[1]	By Supplier	
B-2.2	Model	By Supplier	
B-2.3	Place of Manufacture	By Supplier	
B-2.4	Cell Type	Crystalline Silicon	
B-2.5	Rated Power (Wp) at STC[2]	By Supplier	
B-2.6	Efficiency	At least 21%	

B-3.0 STRING INVERTER

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-3.1	Manufacturer	By Supplier	
B-3.2	Model	By Supplier	
B-3.3	Place of Manufacture	By Supplier	
B-3.4	Rating	By Supplier	
B-3.5	Efficiency	≥95%	

[1] Solar PV module manufacturer shall be included in the latest Tier 1 category list by Bloomberg New Energy Finance in accordance with EW-1.2 Solar PV Modules (e).
[2] For bifacial type PV module, listed maximum power output at 0% bifacial gain on the nameplate shall be considered as the rated capacity of the module.

Name of Firm | Name & Signature of Representative | Designation

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-3.6	Output Voltage (V_{AC})	480 V (nominal voltage adjustable by ±5% via system set points)	
B-3.7	Output Frequency (Hz)	60 Hz, ±0.5%	
B-3.8	Data Interface	Modbus	
B-3.9	Topology	Transformerless	

B-4.0 SOLAR PV PLANT (SPP) TRANSFORMER

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-4.1	Manufacturer / Brand	By Supplier	
B-4.2	Place of Manufacture	By Supplier	
B-4.3	Rated Capacity	At least 75 kVA	
B-4.4	No. of unit/s	1 set	
B-4.5	Number of phase	Three (3)	
B-4.6	Frequency, Hz	60	

B-5.0 ENERGY STORAGE SYSTEM (ESS) TRANSFORMER

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-5.1	Manufacturer / Brand	By Supplier	
B-5.2	Place of Manufacture	By Supplier	
B-5.3	Rated Capacity	At least 75 kVA	
B-5.4	No. of unit/s	1 set	
B-5.5	Number of phase	Three (3)	
B-5.6	Rated operating frequency, Hz	60	

Name of Firm | Name & Signature of Representative | Designation

B-6.0 ENERGY STORAGE SYSTEM

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-6.1	Manufacturer	By Supplier	
B-6.2	Model	By Supplier	
B-6.3	Place of Manufacture	By Supplier	
B-6.4	Nominal Rating (kW)	60+10% overload	
B-6.5	Usable Energy	≥ 60 kWh	
B-6.6	Power Swing (kW)	60	
B-6.7	Reverse Power Swing (kW)	60	
B-6.8	Power Swing and Reverse Power Swing Response time (milliseconds)	≤ 200	
B-6.9	Power Factor	-1 to +1	
B-6.10	Operating Frequency (Hz)	60 Hz	
B-6.11	Technical and Functional Requirements for the Battery Management System, Power Conversion System, ESS Control System and ESS Enclosure/Cabinet as stated in **EW-2.4 ESS**	Required	

B-7.0 BATTERY MODULES

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-7.1	Model	By Supplier	
B-7.2	Manufacturer	By Supplier	
B-7.3	Chemistry	NMC, LMO, Blended LMO / NMC, LFP	

Name of Firm | Name & Signature of Representative | Designation

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-7.4	Gross weight of one Battery Module[3]	By Supplier	
B-7.5	Nominal Capacity (Ah)	By Supplier	
B-7.6	Manufacturer's Track Record	> 5 years	
B-7.7	Current Operational Install Base	At least 1MWh	

B-8.0 POWER AND ENERGY MANAGEMENT SYSTEM

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-8.1	Technical and Functional Requirements as stated in **EW-3.0 PEMS**	Required	
Hybrid Controller[4]			
B-8.2	Manufacturer	By Supplier	
B-8.3	Model	By Supplier	
B-8.4	Place of Manufacture	By Supplier	
Genset Controller			
B-8.5	Manufacturer	By Supplier	
B-8.6	Model	By Supplier	
B-8.7	Place of Manufacture	By Supplier	
Solar/PV Controller[5]			
B-8.8	Manufacturer	By Supplier	

[3] Refer to EW-2.4.2 Battery Modules/Batteries (d).
[4] If the Supplier opt to use CAN communication protocol between PEMS controllers (multi-master structure), the Supplier shall indicate 'Not Applicable' under Hybrid Controller.
[5] If the Solar/PV controller and the ESS Control System/ESS controller is built-in the String Inverter(s) and ESS respectively, the supplier shall indicate the brand and model of the said controllers.

Name of Firm | Name & Signature of Representative | Designation

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
B-8.9	Model	By Supplier	
B-8.10	Place of Manufacture	By Supplier	
ESS Controller/ESS Control System[6]			
B-8.11	Manufacturer	By Supplier	
B-8.12	Model	By Supplier	
B-8.13	Place of Manufacture	By Supplier	

[6] If the Solar/PV controller and the ESS Control System/ESS controller is built-in the String Inverter(s) and ESS respectively, the supplier shall indicate the brand and model of the said controllers.

Name of Firm | Name & Signature of Representative | Designation

SECTION VI

PART II-TECHNICAL DATA SHEETS

ELECTRICAL WORKS

DOCUMENTS TO BE SUBMITTED DURING POST QUALIFICATION

PART II – TECHNICAL DATA SHEETS

EW – ELECTRICAL WORKS

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G-16.0	Standard/Special Tools for Solar PV System	VI-TDS (EW)-PQ-17
G-17.0	List of Other Documents To Be Submitted in Addition To The Technical Data Sheets	VI-TDS (EW)-PQ-17

PART II - TECHNICAL DATA SHEETS

EW – Electrical Works

Technical Requirements

1. The Bidder shall complete and submit this document together with the equipment brochure/technical datasheet of major equipment *(i.e., Solar PV Modules, String Inverters, ESS, Battery Modules, PEMS and Transformers)* during the post-qualification. The Bidder shall use additional sheets as necessary for any other additional information following the format shown herein or by reproducing the same.

2. The Bidder is required to provide all the information required under the Column "Supplier's Data". Although not given by NPC, the Supplier's Data shall be based on the International Standard.

3. NPC's requirements are indicated below. The Supplier shall indicate their data corresponding to the said NPC requirements to facilitate evaluation of Supplier's compliance to the specifications. The data required are technical features and characteristics of the Equipment to be provided by the bidder which shall at least be equal or superior to NPC's requirements.

4. The bidder shall provide copies of the manufacture's and equipment certifications as listed in this document

5. Non submission of the required documents shall be a ground for disqualification.

ANNEX C - SCHEMATIC DIAGRAM

The following ***Documents*** shall be submitted by the Supplier in **sequential order** as listed hereunder as **Annexes** during the post-qualification process. All data and information shall be in English language and shall be drawn using the metric system as unit of measurement.

Annex C	Schematic Diagram of the Proposed Solar PV-Diesel Hybrid Power Plant (with ESS) showing all equipment/components to be furnished including interfacing and communication system of the Solar PV with the Existing Power Plant

Note: ***Failure to submit drawings and documents listed hereunder Annex C shall be ground for disqualification.***

Name of Firm _____ Name & Signature of Representative _____ Designation _____

ANNEX D - ESS Manufacturer's Track Record Data Sheet

Brand and Model	Capacity Installed (MW)	Date Installed	Client's Name	Location	Client's Contact Details (including email address)

Name of Firm

Name & Signature of Representative

Designation

ANNEX E - Battery Module Manufacturer's Track Record Data Sheet

Brand and Model	Capacity Installed (MWh)	Date Installed	Client's Name	Location	Client's Contact Details (including email address)

Name of Firm _____ Name & Signature of Representative _____ Designation _____

ANNEX F - PEMS Manufacturer's Track Record Data Sheet

Brand and Model	No. of Units Installed	Date Installed	Client's Name	Location	Client's Contact Details (including email address)

Name of Firm _____ Name & Signature of Representative _____ Designation _____

G-1.0 SOLAR PV PLANT

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-1.1	Total Number of Modules	By Supplier	
G-1.2	No. of Modules in Series (PV String)	By Supplier	
G-1.3	Number of Parallel Combination (total number of PV strings)	By Supplier	
G-1.4	Number of Inverters	By Supplier	

G-2.0 SOLAR PV MODULES

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-2.1	Manufacturer[1]	By Supplier	
G-2.2	Model	By Supplier	
G-2.3	Cell Type	Crystalline Silicon	
G-2.4	Rated Power (Wp) at STC[2]	By Supplier	
G-2.5	Module Efficiency	At least 21%	
G-2.6	Solar PV Module Service Life	By Supplier	
G-2.7	Rated Voltage (V) at STC	By Supplier	
G-2.8	Rated Current (A) at STC	By Supplier	
G-2.9	Open Circuit Voltage (V_{OC}) at STC	By Supplier	
G-2.10	Short Circuit Current (I_{SC}) at STC	By Supplier	
G-2.11	Power Tolerance	± 3%	
G-2.12	Dimension (L x W)	By Supplier	

[1] Solar PV module manufacturer shall be included in the latest Tier 1 category list by Bloomberg New Energy Finance in accordance with EW-1.2 Solar PV Modules (e).
[2] For bifacial type PV module, listed maximum power output at 0% bifacial gain on the nameplate shall be considered as the rated capacity of the module.

Name of Firm | Name & Signature of Representative | Designation

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-2.13	Weight (kg)	By Supplier	
G-2.14	Junction Box IP Rating	IP65	

G-3.0 STRING INVERTER

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-3.1	Manufacturer	By Supplier	
G-3.2	Model	By Supplier	
G-3.3	Inverter Power Rating (kW)	By Supplier	
G-3.4	Efficiency at Rated Power	≥ 95%	
G-3.5	Input DC Power (kW_P)	By Supplier	
G-3.6	No. of MPPT	At least One (1)	
G-3.7	Input Voltage Range per MPPT (V)	By Supplier	
G-3.8	Maximum Open Circuit Voltage per MPPT (V)	By Supplier	
G-3.9	Maximum Input Current per MPPT (A)	By Supplier	
G-3.10	Maximum Short Circuit Current per MPPT (A)	By Supplier	
G-3.11	Nominal Output Voltage (V)	480 V (adjustable by ±5% via system set points)	
G-3.12	Maximum Output Current (A)	By Supplier	
G-3.13	Number of Phase	Three (3)	
G-3.14	Nominal Output Frequency (Hz)	60 Hz, ±0.5%	
G-3.15	Power Factor at Rated Power Rating	By Supplier	
G-3.16	Total Harmonic Distortion	5%	
G-3.17	Operating Temperature Range (°C)	By Supplier	
G-3.18	Data Interface	Modbus	

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ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-3.19	Topology	Transformerless	
G-3.20	Ingress Protection Rating	IP65	
G-3.21	Over current Protection	Required	
G-3.22	Overvoltage Protection	Required	
G-3.23	Anti-Islanding Protection	Required	
G-3.24	DC Reverse Polarity Protection	Required	
G-3.25	Ground Fault Monitoring	Required	
G-3.26	Grid Monitoring	Required	
G-3.27	PV Array Fault Monitoring	Required	
G-3.28	Residual Current Monitoring	Required	

G-4.0 SOLAR PV PLANT (SPP) TRANSFORMER

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-4.1	Manufacturer/Brand	By Supplier	
G-4.2	Model	By Supplier	
G-4.3	Rated Capacity (kVA)	At least 75	
G-4.4	Number of Phase	Three (3)	
G-4.5	Type of Cooling	ONAN	
G-4.6	Insulation	Mineral Oil with its electrical and chemical characteristics is compliant with IEC and is Polychlorinated Biphenyls (PCB) free	
G-4.7	Type	Two-winding Transformer	
G-4.8	Audible Sound Level	Refer to Table specified under EW-1.10.3.8	
G-4.9	Vector Group	YNd11	
G-4.10	Temperature		

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ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
	• Ambient Temperature (°C)	40	
	• Temperature Rise (C°)	65	
G-4.11	Winding Connection		
	• H-Winding	Wye with Neutral Grounded	
	• X-Winding	Delta	
G-4.12	Insulation Level		
	a. Nominal Voltage Level (kV)		
	• H-Winding	13.8	
	• X-Winding	0.48	
	b. Highest Voltage Level (kV)		
	• H-Winding	15	
	• X-Winding	1.2	
	c. Basic Insulation Level (kV)		
	• H-Winding	95	
	• X-Winding	30	
G-4.13	Winding Material	100% Copper	
G-4.14	Bushing Material	Porcelain	
G-4.15	No. of Bushing	Three (3)	
G-4.16	Impedance at Rated Capacity (%)	Manufacturer's Data	
G-4.17	Efficiency	By Supplier	
G-4.18	Tap Changer	No-Load	
G-4.19	Taps		
	• H-Winding	13.8 kV ± 2 x 2.5%	
	• X-Winding	N/A	
G-4.20	Transformer Losses	By Supplier	
G-4.21	Tolerances		

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ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
	• No-Load & Load Loss	Not more than 10% of the manufacturer's specified value	
	• Total Loss	Not more than 6% of the manufacturer's specified value	
	• Impedance	± 10% of the manufacturer's specified value	
G-4.22	Ground Terminal Connection	Suitable for 100 mm^2 copper conductor	
G-4.23	Weight of Oil (kg)	By Supplier	
G-4.24	Total Weight (kg) (with transformer oil)	By Supplier	

G-5.0 DC BOX

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-5.1	DC Circuit Breakers		
	Continuous Current Rating (A)	By Supplier	

G-6.0 AC COMBINER BOX

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-6.1	Circuit Breakers		
	Continuous Current Rating (A)	By Supplier	

G-7.0 ENERGY STORAGE SYSTEM

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-7.1	Manufacturer	By Supplier	
G-7.2	Model	By Supplier	
G-7.3	Nominal Power Rating (kW)	At least 60	

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ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-7.4	Usable Energy (kWh)	At least 60	
G-7.5	Frequency (Hz)	60	
G-7.6	Battery Management System	By Supplier	
	Charge / Discharge		
	1. Nominal Charge / Discharge Current (A)	By Supplier	
	2. Maximum Charging Current (A)	By Supplier	
	3. Maximum Discharge Current (A)	By Supplier	
G-7.7	Number of Battery Modules	By Supplier	
G-7.8	ESS Enclosure/Cabinet		
	Gross Weight, Installed with batteries (kg)	By Supplier	
	Dimension, Length x Width x Height (m)	By Supplier	

G-8.0 BATTERY MODULES

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-8.1	Manufacturer	By Supplier	
G-8.2	Model	By Supplier	
G-8.3	Chemistry	NMC, LMO, Blended LMO / NMC, LFP	
G-8.4	Nominal Capacity	By Supplier	
G-8.5	No. of Cells per Module	By Supplier	
G-8.6	Electrical Characteristics		

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ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
	• Nominal Terminal Voltage (V_{DC})	By Supplier	
	• Minimum Operating Voltage (V_{DC})	By Supplier	
	• Maximum Operating Voltage (V_{DC})	By Supplier	
	• Maximum Normal State of Charge (MaxNSoC)[3] (%)	By Supplier	
	• Minimum Normal State of Charge (MinNSoC) (%)	By Supplier	
	• Nominal C-rate @ 25°C[4]	1 or higher	
	• Self-discharge Rate per Month (% of its capacity)	≤ 10%	
	• Cycle Lifetime	At least 5000	
G-8.7	Physical Characteristics		
	• Dimension, Length x Width x Height (m)	By Supplier	
	• Maximum Gross Weight (Kg)[5]	By Supplier	
G-8.8	Overcharge Protection	Required	
G-8.9	Short Circuit Protection	Required	
G-8.10	Thermal Runaway Protection	Required	

G-9.0 ENERGY STORAGE SYSTEM (ESS) TRANSFORMER

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-9.1	Manufacturer/Brand	By Supplier	
G-9.2	Model	By Supplier	

[3] As defined under Section VI – Technical Specifications Clause EW-2.1
[4] Refer to EW-2.4.2 Battery Modules/Batteries (b) whenever the Supplier opt to furnish battery modules with less than 1 C-rate.
[5] Refer to EW-2.4.2 Battery Modules/Batteries (d).

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ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-9.3	Rated Capacity (kVA)	At least 75	
G-9.4	Number of Phase	Three (3)	
G-9.5	Type of Cooling	ONAN	
G-9.6	Insulation	Mineral Oil with its electrical and chemical characteristics is compliant with IEC and is Polychlorinated Biphenyls (PCB) free	
G-9.7	Type	Two-winding Transformer	
G-9.8	Audible Sound Level	Refer to Table specified under EW-2.4.7.3.8	
G-9.9	Vector Group	YNd11	
G-9.10	Temperature		
	• Ambient Temperature (°C)	40	
	• Temperature Rise (C°)	65	
G-9.11	Winding Connection		
	• H-Winding	Wye with Neutral Grounded	
	• X-Winding	Delta	
G-9.12	Insulation Level		
	a. Nominal Voltage Level (kV)		
	• H-Winding	13.8	
	• X-Winding	By Supplier	
	b. Highest Voltage Level (kV)		
	• H-Winding	15	
	• X-Winding	By Supplier	
	c. Basic Insulation Level (kV)		
	• H-Winding	95	
	• X-Winding	By Supplier	

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ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-9.13	Winding Material	100% Copper	
G-9.14	Bushing Material	Porcelain	
G-9.15	No. of Bushing	Three (3)	
G-9.16	Impedance at Rated Capacity (%)	Manufacturer's Data	
G-9.17	Efficiency	By Supplier	
G-9.18	Tap Changer	No-Load	
G-9.19	Taps		
	• H-Winding	13.8 kV ± 2 x 2.5%	
	• X-Winding	N/A	
G-9.20	Transformer Losses	By Supplier	
G-9.21	Tolerances		
	• No-Load & Load Loss	Not more than 10% of the manufacturer's specified value	
	• Total Loss	Not more than 6% of the manufacturer's specified value	
	• Impedance	± 10% of the manufacturer's specified value	
G-9.22	Ground Terminal Connection	Suitable for 100 mm^2 copper conductor	
G-9.23	Weight of Oil (kg)	By Supplier	
G-9.24	Total Weight (kg) (with transformer oil)	By Supplier	

G-10.0 POWER AND ENERGY MANAGEMENT SYSTEM

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-10.1	Manufacturer	By Supplier	
G-10.2	Model	By Supplier	
G-10.3	Communication Protocol	Modbus or CAN	

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G-11.0 POWER CABLES[6]

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
15 kV Power Cable			
G-11.1	Manufacturer	By Supplier	
G-11.2	Brand	By Supplier	
G-11.3	Max. continuous current carrying capacity of conductor at 90°C	Manufacturer's Data	
G-11.4	Conductor Cross-Section, mm^2	Refer to Single Line Diagram	
G-11.5	Conductor Material	Annealed Copper	
G-11.6	Insulation Material	Cross-linked polyethylene (XLPE)	
1.5kV DC Power Cable			
G-11.7	Manufacturer	By Supplier	
G-11.8	Brand	By Supplier	
G-11.9	Conductor Size	By Supplier	
G-11.10	Conductor Metal	Tin Annealed Copper Stranded Wire	
G-11.11	Type of Insulation	Refer to EW-1.8(b)	

G-12.0 FUSE DISCONNECT SWITCH WITH LIGHTNING ARRESTER COMBINATION[7]

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-12.1	Manufacturer	By Supplier	

[6] Refer to EW-1.8 and EW-5.4 specifications
[7] Refer to EW-5.0 specifications

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G-13.0 BUS CONDUCTOR AND HARDWARES[8]

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
Stranded Conductor Requirements			
G-13.1	Manufacturer	By Supplier	
G-13.2	Type designation	Aluminum Conductor Steel Reinforced (ACSR)	
G-13.3	Conductor size	1/0	
G-13.4	Ampacity, A	230	
Conductor Hardware			
G-13.5	Tension Clamp		
	a. Type	Bolted, U-Bolt	
	b. Material of Body	Aluminum Alloy	
G-13.6	Connectors		
	a. Type	wedge pressure clamp for stranded conductor connection	
	b. Angle and T-connectors type	wedge pressure clamp for stranded conductor connection	

G-14.0 JOB SITE CAMERAS[9]

ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-14.1	Manufacturer	By Supplier	
G-14.2	Type	Time-Lapse Camera	
G-14.3	Quantity	At least 2 sets	

[8] Refer to EW-5.0 specifications
[9] Refer to EW-1.11

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ITEM	DESCRIPTION	NPC REQUIREMENTS	SUPPLIER'S DATA
G-14.4	Control Display	Thin-Film-Transistor (TFT) Liquid Crystal Display (LCD)	
G-14.5	Image Sensor Resolution	At least 1.3 Megapixel CMOS	
G-14.6	View Angle	At least 110 degrees viewing angle	
G-14.7	Still Image Resolution	1280 x 720	
G-14.8	Time Lapse Interval	15 minutes/ User-programmable	
G-14.9	Battery Type	Standard AA or AAA Size Alkaline Batteries	
G-14.10	Battery Life	At least 120 days of image recording	
G-14.11	Additional Battery (Spare)	To Be Provided	
G-14.12	Enclosure	IPX4 compliant	
G-14.13	Storage Memory	SDHC	
G-14.14	Storage Capacity	32GB	
G-14.15	Additional Storage per camera (Spare)	At least One (1)	

G-15.0 SPARE PARTS FOR SOLAR PV SYSTEM, ENERGY STORAGE SYSTEM(ESS), POWER AND ENERGY MANAGEMENT SYSTEM(PEMS) AUXILIARIES[10] (Minimum Requirements as Specified in the Technical Specifications and Manufacturer's Standard and Recommended Spare Parts)

ITEM	DESCRIPTION	QTY.	SHELF LIFE	INTERVAL OF REPLACEMENT
G-15.1	Memory Cards/ Data Storage	2 units		
G-15.2	Spare Wind Anemometers	3 pcs		
G-15.3	Spare Solar Pyranometer	1 pc		

[10] Refer to GW-7.0

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G-15.4	Spare Thermocouple for solar module temperature	1 set		
G-15.5	Spare Thermocouple for ambient air	1 pc		
G-15.6	Battery Modules[11]	1 pc		
G-15.7	Other spare parts recommended by the **Equipment (SPP, ESS and PEMS) Manufacturer** (Specify)	1 lot		
	1.			
	2.			

G-16.0 STANDARD / SPECIAL TOOLS FOR SOLAR PV SYSTEM[12]

ITEM	DESCRIPTION	QTY.
G-16.1	Tool Box	1 unit
G-16.2	Insulation Resistance Tester (with rated voltage at 250V / 500V / 1000V	1 set
G-16.3	Load Resistor (0-1000 ohms)	1 set
G-16.4	Voltmeter (with a minimum rated voltage of 600VAC and 1kVDC)	1 set
G-16.5	Clamp Meter (with minimum rated current of 500A)	1 set
G-16.6	PVC hose, flexible and robust, 20mm diameter, at least 30m length with drum and reel assembly	1 unit
G-16.7	Extendable/telescopic panel cleaning pole with squeegee and sponge, at least 12ft length with hose attachment (20mm diameter hose)	1 unit

G-17.0 LIST OF OTHER DOCUMENTS TO BE SUBMITTED IN ADDITION TO THE TECHNICAL DATA SHEETS

Manufacturer's Certification Requirements

1. **ISO 9001 Certificate of the Manufacturer** for the following equipment:

[11] Not to be supplied
Notes: Minimum requirements but the Supplier may increase the specified quantity if found not sufficient during Warranty Period.
[12] Refer to GW-8.0

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a. Solar PV (SPV) Modules
b. String Inverters
c. Energy Storage System
d. Battery Modules/Batteries
e. Power and Energy Management System (PEMS)

2. **ISO 14001 Certificate of the Manufacturer or equivalent** for the following equipment:
   a. Solar PV (SPV) Modules
   b. Battery Modules/ Batteries

Equipment Certification Requirements

1. Test Certificates/Certificates of Conformance of the **SPV modules** to be supplied that comply with the following standards:
   a. **IEC 61215** – Crystalline Silicon Terrestrial Photovoltaic (PV) Modules- Design Qualification and Type Approval
   b. **IEC 61730-1** – Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction
   c. **IEC 61730- 2** – Photovoltaic (PV) module safety qualification- Part 2: Requirements for testing
   d. **IEC 61701** – Salt mist corrosion testing of photovoltaic (PV) modules

2. Test Certificates/ Certificates of Conformance of the **String Inverters** to be supplied that comply with the following standards:
   a. **IEC 62109-1** – Safety of power converters for use in photovoltaic power systems- Part 1: General requirements
   b. **IEC 62109-2** – Safety of power converters for use in photovoltaic power systems- Part 2: Particular requirements for inverters
   c. **IEC 62116** – Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures

3. Test Certificates/ Certificates of Conformance of the **Battery Modules** to be supplied that comply with any of the following standards:
   a. **IEC 62619** – Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications; or
   b. **UL 1642** – UL Standard for Safety of Lithium Batteries

Other Requirement

1. Latest Copy of **Bloomberg New Energy Finance List of Tier 1 Manufactures** during bid submission date.
2. **Certificate of Site Inspection** duly signed by the Calutcot DPP Plant-in-Charge and/or its duly authorized NPC personnel.

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SECTION VI

PART II-TECHNICAL DATA SHEETS

ELECTRICAL WORKS

ADDITIONAL DRAWINGS AND DOCUMENTS TO BE SUBMITTED DURING IMPLEMENTATION

PART II – TECHNICAL DATA SHEETS

ANNEX H – ADDITIONAL DRAWINGS AND DOCUMENTS TO BE SUBMITTED DURING IMPLEMENTATION

ANNEX	DESCRIPTION
Annex H.1	Prior to the purchase of materials, equipment and implementation of works, the supplier shall prepare and submit five (5) copies of, but not limited to, the following drawings/documents for review/approval of NPC: a) Civil Drawings: 1. Site Development plan; 2. Topographic survey/layout; 3. Lot or Parcellary survey; 4. Longitudinal and Transverse Section drawings and details; 5. SPP support/structure design and details; 6. Foundation plans and details; i. Energy Storage System Housing; ii. SPP array; iii. ESS transformer; iv. SPP transformer; b) Electrical Drawings: 1. System architecture; 2. Overall single line diagram; 3. SPP single line diagram; 4. ESS single diagram; 5. SPP Design Calculations (including cable and conduit sizing & VD and protection computation); 6. ESS Design Calculations (including cable and conduit sizing & VD and protection computation); 7. SPP cable layout; 8. ESS electrical layout and details (e.g., Lighting and Power Layout, Wiring and Cable Tray Details) 9. SPP and ESS Lightning Protection layout and details; 10. SPP and ESS switchyard layout and details; 11. SPP and ESS grounding layout and details; c) List of recommended Spare Parts and Special Tools; and d) Operation and Maintenance Manuals. Other drawings that are not listed herewith but are deemed necessary for construction of the project shall be submitted to NPC for approval. Plans, schematics, equipment or items supplied or used without such approval shall be at the Supplier's risk of subsequent rejections.

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Annex H.2	**Manufacturer's General Data and Illustrated Catalogues and Brochures** stating the following minimum requirements for the equipment offered: 1. Solar PV Modules a. Manufacturer b. Model c. Cell Type d. Rated Power (W_P) at STC e. Efficiency f. Solar PV Module Service Life g. Rated Voltage (V) at STC h. Rated Current (A) at STC i. Open Circuit Voltage (V_{OC}) at STC j. Open Circuit Current (I_{SC}) at STC k. Power Tolerance l. Dimension (L X W) m. Weight (Kg) n. Junction Box IP Rating 2. String Inverter a. Manufacturer b. Model c. Rating d. Efficiency e. Input DC Power (W) f. No. of MPPT g. Maximum Input Voltage (V_{DC}) h. Minimum Input Voltage (V_{DC}) i. MPP Voltage Range (V_{DC}) j. Maximum Input per MPPT (Input A/ Input B) (A) k. Maximum Short Circuit per MPPT (A) l. Maximum Output Current (A) m. Power Factor at rated power (pf) n. Total Harmonic Distortion o. Connection Phase p. Output Voltage (V_{AC}) q. Output Frequency (Hz) r. Data Interface s. Protection Rating t. Operating Temperature Range u. Topology 3. DC Box a. Protection Rating b. Surge Protection c. DC Circuit Breakers • Continuous Current Rating • Type

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	4. AC Box a. Protection Rating b. Surge Protection c. Circuit Breakers d. Metering System 5. Solar PV Plant (SPP) Transformer a. Manufacturer/Brand b. Model c. Rated Capacity, kVA d. Number of Phase e. Type of Cooling f. Insulation g. Type h. Audible Sound Level i. Vector Group j. Temperature • Ambient Temperature • Temperature Rise k. Winding Connection l. Insulation Level • Nominal Voltage Level • Highest Voltage Level • Basic Insulation Level m. Winding Material n. Bushing Material o. % Impedance p. Efficiency q. Tap Changer r. Taps s. Transformer Losses t. Tolerances u. Ground Terminal Connection v. Weight of Oil w. Total Weight x. Manufacturer's Test Certificate (PCB) y. PCB Analysis Test Result Conducted by the DENR Accredited Laboratories 6. Energy Storage System (ESS) Transformer a. Manufacturer/Brand b. Model c. Rated Capacity, kVA d. Number of Phase e. Type of Cooling f. Insulation g. Type h. Audible Sound Level i. Vector Group j. Temperature

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- Ambient Temperature
- Temperature Rise

k. Winding Connections
l. Insulation Level
   - Nominal Voltage Level
   - Highest Voltage Level
   - Basic Insulation Level

m. Winding Material
n. Bushing Material
o. % Impedance
p. Efficiency
q. Tap Changer
r. Taps
s. Transformer Losses
t. Tolerances
u. Ground Terminal Connection
v. Weight of Oil
w. Total Weight
x. Manufacturer's Test Certificate (PCB)
y. PCB Analysis Test Result Conducted by the DENR Accredited Laboratories

7. Energy Storage System
   a. Manufacturer
   b. Model
   c. Nominal Rating, kW
   d. Usable Energy, kWh
   e. Operating Frequency (Hz)

8. Battery Modules
   a. Manufacturer
   b. Model
   c. Chemistry
   d. Nominal Capacity (Ah)
   e. Electrical Characteristics
      - Nominal Terminal Voltage
      - Minimum Operating Voltage
      - Maximum Operating Voltage
      - Maximum Normal State of Charge
      - Minimum Normal State of Charge
      - Nominal C-rate @ 25°C
      - Self-Discharge Rate
      - Cycle lifetime
   f. Physical Characteristics
      - Length
      - Width
      - Height
      - Gross Weight
      - Number of cells

	g. Safety Protection 9. Power and Energy Management System a. Manufacturer b. Model c. Communication 10. Power Cables 15 kV XLPE Cable a. Manufacturer b. Place of Manufacturer c. Maximum operating Temperature, °C d. Max. continuous current carrying capacity of conductor at 90°C e. Type of cable f. Conductor Cross-Section, mm^2 g. Conductor Diameter, mm h. Maximum Outside Diameter, mm i. Conductor Shape j. Conductor Material k. Insulation (Material & Thickness) l. Outer covering/Jacket (Material, Thickness & Termite Protection Required) m. Shield (Type) n. Filler & Binder Tape 600 V THHN/THWN-2 Cable a. Manufacturer b. Place of Manufacturer c. Maximum operating Temperature, °C d. Max. continuous current carrying capacity of conductor at 90°C e. Conductor Cross-Section, mm2 f. Conductor Diameter, mm g. Maximum Outside Diameter, mm h. Conductor Material i. Insulation (Material & Thickness) 1.5kV DC Cable a. Manufacturer b. Place of Manufacturer c. Conductor Size d. Conductor Metal e. Conductor Shape f. Conductor Material g. Type of wire h. Type of Insulation i. Maximum Operating Temperature 11. Control and Instrumentation Cables General a. Manufacturer

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	b. Place of Manufacturer c. Conductor Size RS-485 a. Type of Conductor b. Shielding c. Type of Insulation d. Type of Jacket e. Impedance Ethernet Cable a. Type of Conductor b. Shielding c. Type of Insulation d. Type of Jacket 12. Grounding System General a. Grid Conductor (Size & Type) b. Bonding Conductor (riser) • All major equipment such as inverter, transformer, ESS, etc. • For motors/pumps rated 30kW and above, CT/PT, FDS & LA • For motors/pumps, perimeter lighting and fence earthing c. Ground Rod (Type, Diameter & Section/Length) 13. Lightning Protection a. Manufacturer b. Place of Manufacturer 14. Lightning Rod a. Material b. Length, mm c. Minimum Diameter, mm 15. Down Conductor a. Type b. Minimum Cross-section Area c. Overall Diameter, mm d. Insulation Material e. Sheath Material f. Weight (kg/m) 16. Accessories a. Support Pipe, Downlead Clamp, Terminal Lug, Guy Wire, PVC conduit, etc. 17. Fuse Disconnect Switch with Lightning Arrester Combination a. Manufacturer b. Place of Manufacturer c. Class (indoor & outdoor)

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d. Rated Voltage, kV
e. Nominal System Voltage, kV
f. Frequency, Hz
g. BIL, kV
h. Ampere Frame
i. Interrupting Capacity, kA
j. Fuse Link (Type & Current Rating)
k. Lightning Arrester
    - Type
    - Class
    - Rated frequency, Hz
    - Nominal system voltage
    - Duty Cycle Voltage (rating), kVrms
    - Maximum Continuous Operating Voltage (MCOV)
    - Nominal discharge current, kA
    - Creepage Distance, mm
    - Supporting brackets, bolts, nuts, etc.

18. Bus Conductor and Line Hardwares

Stranded Conductor Requirements
a. Manufacturer
b. Place of Manufacturer
c. Type of designation
d. Code Name
e. Conductor Size
f. Ampacity, A
g. Outer Layers
    - Material
    - Stranding No.
    - Calculated cross sectional area, mm^2
    - Coefficient of Elongation
h. Core
    - Material
    - Stranding No.
    - Calculated cross sectional area, mm^2
    - Coefficient of Elongation
i. Conductor Coefficient of Linear Expansion

Conductor Hardware
a. Tension clamp
    - Type
    - Material
b. Connectors
    - Type
    - Angle and T-connectors type

19. Job Site Cameras
    a. Manufacturer
    b. Type

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	c. Control Display d. Image Sensor Resolution e. View Angle f. Still Image Resolution g. Time Lapse Interval h. Battery Type & Life i. Enclosure IP Rating j. Storage Memory k. Storage Capacity
Annex H.3	Site Acceptance Test Procedure for the following: a) SPV panels b) String Inverters c) Energy Storage System (as an integrated system) including: • Battery Management System (BMS) • Power Conversion System (PCS) • ESS Control System (ECS) • Battery Modules d) Battery Modules/ Batteries e) Power and Energy Management System (PEMS) including: • Solar/PV Controller(s) • Genset Controllers • ESS Control System/ESS Controller(s)
Annex H.4	Warranty Statement for the following (as stated in GW-19): a) SPV panels at least 10-year warranty b) String Inverters at least 5-year warranty c) Energy Storage System at least 5-year warranty d) Power and Energy Management System at least 5-year warranty e) Battery Modules/ Batteries at least 5-year warranty
Annex H.5	Computation of Performance Ratio and Annual Yield using the latest version of **PVsyst Software** reckoned from the bid opening date.
Annex H.6	**Commissioning Test Procedures** (Refer to Section GW-13.3.3 Commissioning Test) **Performance Test Procedures** (Refer to Section GW-13.4 Performance Test)
Annex H.7	**ISO 9001 Certificate of the Manufacturer** for the following equipment: a) Solar PV (SPV) Modules b) String Inverters c) Energy Storage System d) Battery Modules/Batteries e) Power and Energy management System (PEMS)
Annex H.8	**ISO 14001 Certificate of the Manufacturer or equivalent** for the following equipment: a) Solar PV (SPV) Modules b) Battery Modules/ Batteries
Annex H.9	**Manufacturer's Certificate on the Average Service Life of the SPV Modules** to be supplied
Annex H.10	Test Certificates/ Certificates of Conformance of the **SPV modules** to be supplied that comply with the following standards:

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	a) IEC 61215 – Crystalline Silicon Terrestrial Photovoltaic (PV) Modules- Design Qualification and Type Approval b) IEC 61730-1– Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction c) IEC 61730- 2– Photovoltaic (PV) module safety qualification- Part 2: Requirements for testing d) IEC 61701 – Salt mist corrosion testing of photovoltaic (PV) modules
Annex H.11	Test Certificates/ Certificates of Conformance of the **String Inverters** to be supplied that comply with the following standards: a) IEC 62109-1- Safety of power converters for use in photovoltaic power systems- Part 1: General requirements b) IEC 62109-2- Safety of power converters for use in photovoltaic power systems- Part 2: Particular requirements for inverters c) IEC 62116 – Utility-interconnected photovoltaic inverters- Test procedure of islanding prevention measures
Annex H.12	Test Certificates/ Certificates of Conformance of the **Battery Modules** to be supplied that comply with any of the following standards: a) IEC 62619 – Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications; or b) UL 1642 – UL Standard for Safety of Lithium Batteries
Annex H.13	Latest Copy of **Bloomberg New Energy Finance List of Tier 1 Manufactures** from bid submission date.
Annex H.14	**Control Logic Block Diagram or Process Flow** of all the controls and functions of Power and Energy Management System as enumerated in *GW-13.3.3 Commissioning Test*.

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