GOVERNMENT OF KHYBER PAKHTUNKHWA
COMMUNICATION & WORKS DEPARTMENT

Dated Peshawar the 30/07/2025

NOTIFICATION:

NO.SO(B)/II-10/Solar-Panels/PBC/2025-26/C&WD: In pursuance of the decisions of the Standardization Committee notified vide P&D Department letter No: Chief/INF/P&D/601/03/2017/378-483 dated 21/02/2017 in its meetings held on 22/05/2025, 02/06/2025, 08/07/2025, & 21/07/2025, the competent Authority upon the recommendations of the committee regarding up-gradation / revision of specifications for solar panels & allied equipment's notified vide this Department Notification No. SO(B)II-10/Standardization/2024-25/C&WD dated 23/05/2025 , has been pleased to approved the **"Revised Specifications For Supply & Installations of: (i) Solar based Pumping Systems (ii) Soar Buildings/ Home Systems (iii) Solar Street Lights"** attached as **"Annex-A"**.

SECRETARY C&W DEPARTMENT

Endst: NO.SO(B)II-10/ Solar-Panels/PBC/2025-26/C&WD. Dated 30/07/2025

Copy forwarded to the:-

1. All Administrative Secretaries, Government of Khyber Pakhtunkhwa.
2. All Chief Engineers C&W Department.
3. Chief Engineer (Renewable), PEDO Peshawar.
4. Project Director (Solar), PEDO Peshawar.
5. Superintending Engineer, PHE Department.
6. Superintending Engineer (HQ), Irrigation Department.
7. Director Engineering, Agriculture Department.
8. Director IT, C&W Department to upload the Revised Specifications on C&W website, please.
9. Deputy Director (Tech), PHE Department.
10. Senior CPO, Energy & Power Department.
11. PS to Secretary Communication & Works Department, Peshawar.
12. Master file.

SECTION OFFICER (BUILDINGS)

Annex-A

REVISED SPECIFICATIONS FOR SUPPLY AND INSTALLATIONS OF:

- **SOLAR BASED PUMPING SYSTEMS**
- **SOLAR BUILDINGS / HOME SYSTEMS**
- **SOLAR STREET LIGHTS**

Year 2025
Version-02
Dated: 08-07-2025

ALL DEPARTMENTS OF
GOVERNMENT OF KHYBER PAKHTUNKHWA

A-SPECIFICATIONS FOR SOLAR SYSTEMS-COMMON PART

1. SOLAR PANELS:

a. The PV module(s) shall contain N-Type Mono crystalline silicon Grade-A Solar cells (Bifacial Double Glass Modules due to its better performance will be given preference).

b. The PV module should Work well with high-voltage input Inverters/ charge controllers (≥1500 Vdc).

c. The PV Panel must have clear anodized aluminium frame with Anti-reflective, hydrophobic, low-iron Tempered cover glass.

d. The Solar Modules shall meet the following valid IEC Standards or latest:

- (IEC 61215-1:2021, IEC 61215-1-1:2021 & IEC 61215-2:2021) (Design Qualification)
- IEC61730-1:2023 (Safety - Requirements for construction)
- IEC61730-2:2023 (Safety - Requirements for testing)
- IEC TS-62804-1-1:2020 (i.e.: TUV PPP-58042B or Equivalent) Anti-PID Certification.
- IEC 61701:2020 Salt Mist Corrosion Resistance Test.
- IEC 62716 Ammonia Corrosion Resistance Test (Latest).
- IEC 60068-2-68 (PPP 59022A) Sand and Dust Erosion Resistance Test.

e. Unique Serial number, Name / Logo of manufacturer and separate date of manufacturing (DD/MM/YYYY) should be laminated inside the module so as to be clearly visible from the front side / Factory Acceptance Test (FAT), for Verification of Manufacturing Facility / Process and Product.

f. A properly laminated sticker containing the following details should be available at the back side of the module.

- Name of the manufacturer / distinctive logo
- Model Name and Type of Cell Technology
- Peak Watt Ratting (Wp) and Power Tolerance Range
- Voltage (V_{mp}) and Current (I_{mp}) at STC
- Open Circuit Voltage (Voc) and Short Circuit Current (Isc)
- Minimum System Voltage (V_{dc}) (i.e.: ≥ 1500 Vdc)
- Test Standard(s) to which the module has been tested and certified

g. Following essential technical parameters of solar panel/modules should be provided with each panel supplied as well as in the technical proposal.

- I-V curve for the solar photovoltaic module/panel.
- Date and year of obtaining IEC PV module standardization qualification certificate.
- Electrical Data (i.e.: Pmax, Voc/Vmp, Isc/Imp at nominal Cell Operating Temperature (NOCT).
- PV Module efficiency at STC.
- Working temperature range of PV Module.

h. Each panel should have factory equipped weather proof terminal junction box having at least IP67 protection with provision of opening for replacement of DC cables, blocking diodes and easy debugging if necessary.

i. Limited performance guarantee: panel power, in standard conditions, will not be less than 90% of nominal power by the end of 10 years of operation and at least 80% at the end of 25 years of operation with 25-year limited power warranty.

j. The PV Module should have at least 10-years warranty for any defects and efficiency as mentioned above. It should be provided On Stamp Paper (Signed and Stamped by Contractor) at the time of Handing/Taking Over or signing of contract agreement.

k. The PV modules shall have a minimum efficiency of 22.0%, along with positive power tolerance. However, for solar street lighting projects, a module efficiency of 17.5% with positive power tolerance shall remain acceptable.

l. The PV modules offered should not be more than 12 months old from the date of issue of work order.

m. PV Module should have minimum Snow Load bearing of 5400 Pa and Wind Load Bearing of 2400 pa however if department deem appropriate may go for 3800 pa wind loads depending upon their requirement.

n. The Solar Module should be free from visual and cosmetics defects.

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o. The department/consultant on the expense of contractor/supplier shall verify Flash test reports with serial numbers from manufacturer for each panel (at the time of supply).

p. All information regarding solar panel with above mentioned featured data should be accessible and verifiable online on the manufacturer website.

q. IEC Certification should be accepted only from an IEC accredited lab for Solar Panels.

r. Electroluminescence (EL) test may be performed randomly for each project at the cost of contractor/supplier.

Note: For the purpose of verification/ third party validation the Electroluminescence (EL) and Flash testing of randomly sampled PV modules should be conducted.

2. CABLES, WIRING AND PROTECTION DEVICES:

a. The AC/DC cables shall be made of 99.9% (allowing a tolerance of ±0.1%) copper strands and flexible.

b. From PV Panel to Junction Box / T-Branch / Inverter, use single-core, double-insulated (UV-stabilized cables with XLPO insulation and XLPO/PVC sheathing). Cables must be stranded or flexible type and shall preferably conform to EN 50618 or IEC FDIS 62930 standards.

c. From JB to Inverter, the DC cable must have Single core, double insulated and suitable for minimum ≥ 1500 V_{DC} transmission.

d. From Inverter to batteries, the DC cable can be single insulated, Single Core and suitable for minimum ≥ 600 V_{DC} transmission.

e. DC circuit breakers / Fuse of ≥ Voc of String Voltage and suitable ampere rating (1.25 to 1.50 Times of Rated Current of all strings connected) must be installed between PV modules and controller / inverter.

f. AC Circuit Breaker (s) of suitable rating (1.25 to 1.50 Times of connected Load) must be installed between Controller / inverter to Load and Grid to Controller / Inverter.

g. AC / DC breakers should be marked with the manufacturer model number, rated voltage, ampere rating and batch/serial number.

h. DC / AC breakers rating should be approved from Engineer In-charge before installation at site.

i. To prevent solar panels from damage an appropriate size of DC Breaker / Fuse should be installed for each PV string and Surge Protection should be installed for combined Array (before Main DC Breaker / Inverter).

j. DC Breaker, AC Breaker & Change overs should be placed in Junction box. For outdoor installation Junction boxes should be Hot Dipped Galvanized with minimum thickness of 16 SWG.

k. Cables shall be clearly labelled with essential electrical parameters including manufacturer name, Voltage Range, standards etc.

l. All DC Wiring shall be aesthetically neat and clean, over-all wiring/connection losses shall not exceed 1% of the total rated output power.

m. All connections/ socket outlet among array, controller, inverters, batteries, and pumping set etc must be made in junction boxes of adequate protection level.

n. All wires/cables should be in standard flexible UV-Resistant conduits / HDPE of PN12, SDR 13.6, PE100 for outdoor installation & (1-3 feet deep) for underground wiring / Cabling and PVC ducts for indoor installation.

o. The DC Combiner Junction Box should be properly earthed including earthing of door as well.

p. The DC Combiner should contain proper bus bars of adequate size each for Positive, Negative and Earthing.

q. The Inverter Junction Box should be properly earthed as well as per vetted design of the Engineer in charge.

r. All wiring should be in proper conduit of capping casing. Wire should not be hanging loose.

s. All wires should be terminated properly by using lugs / thimble connectors / sleeves.

t. Distribution board must be installed with proper screws.

u. Electrical Hazards Safety Labels should be pasted on DC Combiner /VFD Enclosure / Charge Controller /Battery Enclosures.

v. Following third party lab tests are mandatory:
Conductor resistance test, Insulation resistance test, Pressure test & Spark test, copper purity test, cable size test or any other necessary tests recommended by Engineer.

w. DC Cable from PV Module to Junction Box / Inverter for each string should be 6 mm^2.

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x. DC Cable Sizing from Junction Box to Inverter (up to cable length of 200 ft) as per details below;

S. No	Nos of Strings	Cable Size ((mm^2))	Remarks
1	1	6	If Cable length is >200 ft (One Sided) than cable size should also be increased accordingly.
2	2	10	
3	3	16	
4	4-5	25	
5	6-8	35	

y. Over Voltage / Current Protection Device may be installed between Utility & Inverter.

z. Surge Protection may be installed for combined Array (before Main DC Breaker / Inverter).

aa. Cable colour coding should be adopted in accordance with relevant international standards.

Note: To ensure compliance with the above specification, the Conductor resistance test, Insulation resistance test, Pressure test, Spark test, copper purity test & cable size test may be conducted through any accredited laboratory in Pakistan.

3. PANEL MOUNTING & STRUCTURE:

a. The panel mounting and structure should be made of hot dipped (80 microns Average) galvanized steel of minimum thickness of **12 SWG Channel / Pipe or 8 SWG Angle** (Sketch and Profile of channel / Angle is Attached for Reference).

b. A sketch of the mounting frame (As per Actual Site Requirements) showing dimensions of the frame parts should be provided at the time of supply.

c. PV to ground clearance must not be less than 1.0 feet. The height of the upper edge of the structure should be up to 10 feet above the ground / Roof top Installations.

d. To avoid Shading, Distance between two rows of PV panels and from walls should be maintained at a minimum of 1.6 times the height of structure/walls. PV shading analysis may be conducted using Helioscope, SketchUp, PVSOL, PVsyst, or any other suitable software or tool.

e. For ground-mounted installations, the concrete foundation pit size shall be a minimum of 1.5 ft x 1.5 ft x 2.0 ft for each individual leg, or 1.5 ft x 3.0 ft x 2.0 ft for a double-leg structure. The concrete must extend at least 1.0 ft above the ground level. For rooftop installations, the civil foundation blocks for each individual leg should be approximately 0.7 ft to 1.0 ft (length) × 0.7 ft to 1.0 ft (width) × 0.7 ft to 1.0 ft (depth), depending on structural requirements. The concrete mix ratio shall be 1:2:4 for all civil works.

f. The Surface azimuth angle of PV Module 180° ± 30° and the Tilt angle (slope) of PV Module be preferably 33° ± 15°. As per site requirements, further azimuth / tilt angle changes (if required) can be made with the approval of Engineer In-charge.

g. The PV modules will be mounted on metallic structures of adequate strength and appropriate design, which can withstand load of modules and high wind velocities up to 150 km per hour.

h. Due to land non-availability or any other problem, Structure design can be modified as per site requirement. Pole Mounted or manual Tracker or H beam Mounting Structure with (Enamel Paint & Red -Oxide) can be provided with the approval of Engineer In-Charge.

i. Array fasteners (nut/bolts/washers) between PV Module and Structure shall be stainless steel (Non-Magnetic). Washers should be installed on both sides of Module frame.

j. The minimum space between two PV Modules should be 2.54 cm (1 inch), to avoid air push over PV Modules.

k. Mechanism / arrangement for cleaning of PV Panels should be provided. i.e.: Space / ladder between panels or at the back side of structure, so that the operator can safely climb and clean the panels.

l. All other array fasteners Structure shall be stainless steel (Non-Magnetic) or Hot Dipped galvanized steel that provides the required mechanical strength. Washers should be installed on both sides.

m. The PV modules will be mounted on metallic structures at the inner holes for cantilevered installation, which will evenly distribute the load of the panel around the support structure on both sides and in the middle.

n. All fabrication work (welding, cutting, or drilling) and structural modifications must be completed prior to the galvanization.

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Note: For strength and durability of the Mounting Structure the stress & strain test may be conducted from any accredited laboratory of Pakistan.

4. EARTHING/ GROUNDING:

a. The PV panel frame, supporting structure, electrical cabinet, protection devices, and all associated equipment should be grounded using the shortest practical route to an effective earth point with a low resistance (ohmic) value, in accordance with the equipment manufacturer's recommendations and site-specific soil conditions. An uninterrupted grounding conductor shall be employed to maintain electrical continuity. Effective grounding significantly reduces the risk of damage from lightning-induced surges and electrical faults.

b. The Sizing of Earthing conductor will be done as per NEC Table 250.122 (Mentioned at Appendix-VI).

c. The grounding conductor should be 99.9% (allowing a tolerance of ±0.1%) copper and PVC insulated / Bare Copper if installed underground along a defined path where size & Design shall be approved from Engineer In-charge before installation at site.

d. Motor, inverter, Battery / Battery Box (if required), Main Distribution Board should be connected to an adequate earth contact / Grounding.

e. Ground enhancement material (GEM) shall be used below and above the Earthing plate for proper grounding. Gravel or coarse sand shall be poured along with soil in the pit.

f. Grounding / Earthing plate should be made of copper plate of 4mm thickness & Size minimum 1.0 x 1.0 Ft.

g. Grounding / Earthing conductor should be connected to the plate / Rod / GI Pipe by proper connector of minimum depth of 6 feet.

h. All nut / bolt and Earthing clamp shall be stainless steel or galvanized steel or any other material as per approval of Engineer In-Charge.

i. Alternatively, Earthing Rod/Plate of suitable size and length can be installed, if given / mentioned in the BOQ/Design and Engineer In-Charge Approval.

Note: The copper purity test for the Earthing Rod/ Plate/ Cable may be conducted through any accredited laboratory in Pakistan.

5. BATTERIES:

a. The battery should be Deep Cycle, GEL, OPzV/OPzS, Lithium LiFePO4, Sodium-ion, Lead Carbon, Super Capacitor based Battery or equivalent.

b. The battery must ensure safe and reliable operation in the whole range of ambient temperatures from -5° C to + 50° C.

c. The maximum permissible self-discharge rate should not be more than 5 percent of rated capacity per month at 25° C.

d. The battery shall have a certificate of compliances, issued by a recognized laboratory.

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f. The battery shall meet the requirements and recommendations given in IEC 61427, IEC 60896 21/22 (For VRLA) or equivalent. Lab Test Reports for battery/Cell cycle life (All Batteries Type) should be provided.

g. The Battery must support parallel and series connection to allow for capacity expansion in the future. Each Battery should have followed minimum information printed on battery:
   - Model Number, Serial Number and Type of battery.
   - Rated Voltage and Capacity (AH) at 25°C at discharge rate of 10 Hours.
   - Origin of made.
   - Manufacturer Name / distinct logo.

h. The following information must be provided in the data sheet while submitting technical bid.
   - Certification/Test Standard(s) of the battery.
   - Information regarding cycles & self-discharge rate.

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i. In case of rechargeable battery bank (having more than one battery), the interconnection shall be made using lead plated copper bus bars or properly insulated flexible copper conductors.
j. Battery disconnect switch / breaker of suitable size should be installed between batteries and inverter / charge controller.
k. The Battery must have Low self-discharge rate, No memory effect and No gassing.

Note: The battery Capacity (kWh) test along with charge & discharge curves may be conducted through any accredited laboratory in Pakistan.

5.1 GEL BATTERIES:

5.1.1 Cycle life of the GEL battery (12V) must be minimum **1000** cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25°C (before reaching 80% capacity of its Initial Capacity).

5.1.2 Cycle life of the GEL battery (2V Cell) must be minimum **1300** cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25°C (before reaching 80% capacity of its Initial Capacity).

5.1.3 The Batteries should have two-years Comprehensive replacement warranty.

5.2 LEAD CARBON:

5.2.1 Cycle life of the Lead Carbon battery (12V) must be minimum **2000** cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25°C (before reaching 80% capacity of its Initial Capacity).

5.2.2 Cycle life of the Lead Carbon battery (2V) must be minimum **2500** cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25°C (before reaching 80% capacity of its Initial Capacity).

5.2.3 The Batteries should have two-years Comprehensive replacement warranty.

5.3 OPzV / OPzS BATTERIES:

5.3.1 Cycle life of the OPzV / OPzS battery (12V) must be minimum **2000** cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25°C (before reaching 80% capacity of its Initial Capacity).

5.3.2 Cycle life of the OPzV / OPzS battery (2V Cell) must be minimum **2500** cycles @ 50% depth of discharge (DOD) at discharge rate of 0.1C@25°C (before reaching 80% capacity of its Initial Capacity).

5.3.3 The Batteries should have two-years Comprehensive replacement warranty.

5.4 LITHIUM BATTERIES (LiFePO4):

5.4.1 Cycle life of the Lithium LiFePO4 battery must be minimum 5750 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.5C@25°C (before reaching 80% capacity of its Initial Capacity).

5.4.2 The battery shall comply with the requirements and recommendations outlined in IEC 62619:2022, issued by a recognized and accredited laboratory.

5.4.3 Lab test reports from a third-party laboratory verifying the claimed battery/cell cycle life shall be provided.

5.4.4 The LiFePO4 battery shall be covered by a comprehensive replacement warranty for a minimum of five (05) years.

5.4.5 The battery shall be equipped with an integrated Battery Management System (BMS) (Preferably active BMS) to ensure operational safety, reliability and communication with inverter or Charge Controller.

5.4.6 The BMS of the battery must have the following features but not limited to:

- Temperature protection
- Over charge protection
- Low voltage disconnects
- High Voltage Disconnect
- Short circuit alarm function

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- Self-balancing function
- Over-current protection
- Over-discharge protection

5.4.7 The LiFePO4 Battery must have LCD status and alarm indication.

5.4.8 The battery pack shall have a minimum ingress protection rating of IP30 or higher.

5.4.9 The charge and discharge rate shall be designed for 0.5 C minimum, but the battery must be capable of handling 1 C charge and discharge rates.

5.4.10 The battery shall be equipped with communication ports such as CAN/CAN/RS485/RS232 OR EQUIVALENT (one port for monitoring settings/data integration and one port for communication with inverter/Charge controller). Additionally, the BMS may have a wireless communication capability, such as Bluetooth, for monitoring, settings adjustment, and calibration purposes.

5.4.11 The above-mentioned specifications and details shall be clearly included in the data sheet, user manual, and all other relevant supporting documents submitted as part of the bid.

5.5 SUPER CAPACITOR BASED BATTERY BANK:

5.5.1 Cycle life of the Super Capacitor based must be minimum **0.1 million** cycles @ **100%** depth of discharge (DOD) at discharge rate of 1C@25°C (before reaching 80% capacity of its Initial Capacity).

5.5.2 The battery must have **an Active** Integrated Battery Management System (BMS) to ensure battery safety and reliability.

5.5.3 The Battery must have a Display LED for battery Voltage, Amperes etc and should have alarm indications.

5.5.4 The charge and discharge rate of the battery must be designed at **1C minimum** and also capable of handling **continuously 1C Charge** and discharge currents.

5.5.5 Warranty of battery for free repair & replacement should be minimum **Five years.**

5.5.6 Nominal Temperature for Super Capacitor battery shall be minimum -10 to +55 degree Celsius.

5.5.7 Super Capacitor battery shall be Non-flammable. (i.e.: Super Capacitor Cells should be non-petroleum based).

Note:

- **Product brochure, Catalogue and certificates must be attached with the Technical Bid.**
- Battery Capacity test should be conducted by the contractor through accredited third-party laboratories within Pakistan

6. BOX / STAND FOR BATTERIES, CHARGE CONTROLLER/INVERTER AND PROTECTION DEVICES:

a. The batteries should be housed in a vented compartment/stand that prevents users from coming in contact with battery terminals. This compartment/stand should be strong enough to accommodate the weight of the battery.

b. A locking mechanism shall be provided to restrict unauthorized access to the battery compartment.

c. The enclosure shall be manufactured from mild steel of at least **18 SWG** thickness.

d. The cabinet shall be hot-dip galvanized or powder-coated or Enamel Paint with Red Oxide, as mentioned in the BOQ.

e. The entire enclosure/stand must be constructed to last at least twenty years without maintenance and should be protected against corrosion. The enclosure should have a clean and neat appearance. The entire enclosure/stand must have a neat, clean, and professional appearance, and the battery box/stand should be installed at a location suitable to the user's preference.

f. The cabinet must be insulated with rubber corks/ covers at each cabinet leg to prevent direct contact with metal surfaces, ground, or other objects, enhancing safety and stability.

g. The cabinet shall have a designated area for mounting a user manual or instruction guide, along with the Site ID label.

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h. Provisions shall be made for the installation of protection devices such as fuses, breakers, and disconnect switches, as well as a clearly marked earthing point.
i. All internal wiring shall be done in proper ducts and labeled for easy identification and maintenance.
j. The cabinet shall include designated areas for labeling/stickering of all internal and external components for quick reference and identification.
k. The cabinet shall incorporate sufficient ventilation slots or louvers to allow for natural airflow and heat dissipation, while protecting against dust and moisture.
l. Cable glands shall be provided at appropriate locations to ensure secure and protected cable entry/exit.
m. The design shall feature rounded corners or edge protectors to reduce injury risk during handling or maintenance.
n. The cabinet shall have minimum Ingress protection of IP-21 or above.
o. The cabinet may optionally support transparent panels to facilitate visual inspection and operational visibility.
p. Pre-drilled mounting holes or brackets shall be available inside the cabinet for optional installation of circuit protection accessories.
q. Clear and permanent safety signage such as polarity indicators, high voltage warnings, and earthing symbols on steel stamp shall be displayed on cabinet.
r. Cabinets shall be properly wrapped and protected before shipment from the warehouse to the site to prevent any unnecessary damage during transportation and handling.
s. The cabinet shall be installed with a minimum clearance of one foot above the finished floor level to ensure protection against moisture, dust, and other potential hazards.
t. The Cabinet for modular installation should be in racks with proper insulation (preferably rubber insulation).

6. (A) <u>SOLAR CHARGE CONTROLLER (FOR SOLAR DC SYSTEM):</u>

a. The controller shall support multiple battery types, including:
   - Flooded Lead-Acid (FLA)
   - GEL
   - Absorbent Glass Mat (AGM)
   - OPzV
   - OPzS
   - Lithium Iron Phosphate (LiFePO4)/Super Capacitor

b. The charge controller shall be certified in compliance with international safety and performance standards, including but not limited to:
   - IEC 62109-1/ IEC 62509

c. The controller shall meet the following Ingress Protection (IP) ratings:
   - IP30 or higher for indoor installation
   - IP65 or higher for outdoor installation

d. The controller shall utilize Single MPPT (Maximum Power Point Tracking) technology to optimize solar input performance.
e. The MPPT tracking efficiency shall be ≥ 99%, and the overall energy conversion efficiency shall be ≥ 95%.
f. The controller shall include automatic temperature compensation functionality to adjust charging parameters based on ambient temperature conditions, protecting battery health.
g. The device shall provide comprehensive protection features, including but not limited to:
   - PV short-circuit protection
   - PV reverse polarity protection
   - PV over-voltage protection
   - PV over-current protection
   - Battery overcharging protection
   - Battery over-discharging protection
   - Battery reverse polarity protection
   - Load short-circuit protection
   - Overload protection
   - Reverse current flow protection from battery to PV modules

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h. The controller shall be equipped with an efficient thermal management system, including a properly dimensioned passive or active heat sink, to maintain safe operating temperatures.
i. The charge controller shall include an CAN/RS485/RS232 OR EQUIVALENT communication port as standard. Support for additional communication protocols such as CAN, RS232, Wi-Fi, or Bluetooth shall be considered an added advantage.
j. The controller shall be capable of operating in battery-less mode, delivering power to DC loads directly from PV modules where applicable.
k. The controller shall be capable of communicating with LiFePO4 batteries via compatible communication interfaces, ensuring seamless integration with Battery Management Systems (BMS).
l. The controller shall feature a digital interface, either integrated (LCD) or external, capable of displaying real-time operational parameters including:
   - PV voltage and current
   - Battery voltage and current
   - State of Charge (SOC) Preferred
   - Load status
   - Faults and alarms
m. The controller may support data logging and remote monitoring features through compatible software or web-based platforms.
n. The controller shall support user-configurable charging algorithms or automatic detection for the connected battery type.
o. Operating temperature range shall be -20°C to +60°C.
p. The charge controller should allow for wall, DIN-rail, or panel mounting, with proper size and clearly labelled wiring terminals. Mounting accessories should be included.

Note: The efficiency test along with all protection features test may be conducted from the accredited laboratory in Pakistan.

6. (B) **All-in-One/Solar kit/Standalone Solar Systems must include the following features:**

a. The all-in-one solar solution must include an MPPT charge controller (DC) or a hybrid inverter (AC), a LiFePO4 battery, and properly sized protection devices (breakers/fuses) for the PV modules, battery bank, and load connections, as per requirements and specifications in Section A (2). The type of solution—whether DC or AC—shall be specified in the BoQ.
b. BMS (preferably active) communication between LiFePO4 Battery and MPPT Charge Controller/ Hybrid Inverter.
c. Heat dissipation with proper heat sinks and cooling fans equipped with a fan controller must be available in case of IP-30 enclosure with proper heat sinks mechanism must be adopted.
d. USB Mobile Charging Port must be available.
e. The all-in-one must have individual ports for various load connectivity.
f. DC All-in-One/Solar kit/Standalone Solar Systems, shall comply with relevant and applicable IEC standards (IEC 62257-9-5:2024) or latest.
g. The All-in-one shall be equipped with communication port such as CAN/RS485/RS232 or equivalent for monitoring settings/data integration. Additionally, the BMS may have a wireless communication capability, such as Bluetooth, for monitoring, settings adjustment, and calibration purposes.
h. The All-in-one shall feature a digital interface, either integrated LCD/ LED, capable of displaying real-time operational parameters including:
   - PV voltage and current
   - Battery voltage and current
   - State of Charge (SOC)
   - Load status
   - Faults and alarms
   - Any other parameters as per project requirement
i. Wide PV voltage input range to support various panel configurations under IEC standards.
j. The all-in-one enclosure shall be manufactured from mild steel of at least 16 SWG thickness for durability and rigidity.
k. The all-in-one enclosure shall be hot-dip galvanized/ Powder-coated/ Enamel Paint with Red Oxide with technical parameters tag including Brand Name, Product name, Model, Serial number,

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Manufacturing date, Input/ Output Power range, Input/ Output Voltage range, Input/ Output current range and Battery capacity.

l. The enclosure must be insulated with rubber corks/ covers at each enclosure leg to prevent direct contact with metal surfaces, ground, or other objects, enhancing safety and stability.
m. The all-in-one enclosure design shall feature rounded corners or edge protectors to reduce injury risk during handling or maintenance.
n. The all-in-one enclosure shall be properly packed and protected prior to shipment from the manufacturer's warehouse to the site, to prevent any damage during transportation and handling.
o. The requirements for LiFePO4, MPPT Charge Controller (DC) / Hybrid inverter (AC) detail are as under:

(1) Battery Bank (LiFePO4):

a. Cycle life of the Lithium LiFePO4 battery must be minimum 5750 cycles @ 50% depth of discharge (DOD) at discharge rate of 0.5C@25°C (before reaching 80% capacity of its Initial Capacity).
b. Lab test reports from a third-party accredited laboratory verifying the claimed battery/cell cycle life shall be provided.
c. The maximum permissible self-discharge rate shall not exceed 5% of the rated capacity per month at 25°C.
d. The LiFePO4 battery shall be covered by a comprehensive replacement warranty for a minimum of five (05) years.
e. The battery shall be equipped with an integrated Battery Management System (BMS) (Preferably active BMS) to ensure operational safety, reliability and communication with MPPT Charge Controller/On-Grid Hybrid solar system.
f. The BMS of the LiFePO4 battery must have the following features but not limited to:
   - Temperature protection
   - Over charge protection
   - Low voltage disconnects
   - High Voltage Disconnect
   - Short circuit alarm function
   - Self-balancing function
   - Over-current protection
   - Over-discharge protection
g. The charge and discharge rate shall be designed for 0.5 C minimum, but the battery must be capable of handling 1 C charge and discharge rates.

(2) In case of DC all-in-one/solar kit/standalone solar systems:

a. The controller shall be capable of communicating with LiFePO4 batteries via compatible communication interfaces, ensuring seamless integration with Battery Management Systems (BMS).
b. The controller shall utilize Single MPPT (Maximum Power Point Tracking) technology to optimize solar input performance.
c. The controller shall include automatic temperature compensation functionality to adjust charging parameters based on ambient temperature conditions, protecting battery health.
d. The device shall provide comprehensive protection features, including but not limited to:
   - PV over-voltage protection
   - PV over-current protection
   - Battery overcharging protection
   - Battery over-discharging protection
   - Battery reverse polarity protection
   - Short Circuit Protection for PV, battery bank and load connections
   - Overload protection
   - Reverse polarity protection for PV & battery bank connections
   - Low Voltage Disconnect (LVD) and Reconnect (LVR) to protect battery from deep discharge and allow safe reconnection
e. The controller shall be equipped with an efficient thermal management system, including a properly dimensioned passive or active heat sink, to maintain safe operating temperatures.

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f. The controller shall be capable of operating in battery-less mode, delivering power to DC loads directly from PV modules where applicable.
g. The controller shall support data logging and remote monitoring features through compatible software or web-based platforms.
h. The controller shall support user-configurable charging algorithms or automatic detection for the connected battery type.
i. The MPPT tracking efficiency shall be ≥ 99%, and the overall energy conversion efficiency shall be ≥ 95%.

(3) In case of AC all-in-one/solar kit solar systems:

a. The inverter shall be capable of communicating with LiFePO4 batteries via compatible communication interfaces, ensuring seamless integration with Battery Management Systems (BMS).
b. Minimum 95% Conversion Efficiency at Rated Capacity (High Frequency Inverters).
c. The Maximum power point tracking MPPT efficiency ≥ 99%, and converter efficiency ≥ 92%.
d. The inverter should have built-in single MPPT controller.
e. Hybrid Inverter (If quoted along with Lithium Batteries) may be capable of communication with the BMS of Lithium Batteries.
f. Rated output voltage of inverter / Controller shall be pure sine wave AC.
g. Total harmonic distortion (THD) in AC output should not exceed 3% at rated capacity.
h. Wide input voltage range capability. (i.e.: Voltage Range can be adjustable / selectable)
i. The device shall provide comprehensive protection features, including but not limited to:
   - PV over-voltage protection
   - PV over-current protection
   - Battery overcharging protection
   - Battery over-discharging protection
   - Battery reverse polarity protection
   - Short Circuit Protection for PV, battery bank and load connections
   - Overload protection
   - Reverse polarity protection for PV & battery bank connections
   - Low Voltage Disconnect (LVD) and Reconnect (LVR) to protect battery from deep discharge and allow safe reconnection.

6. (C) BRACKET FAN SPECIFICATIONS:

a. Fan Size: 14-16 inches
b. Sweep Size: 350 mm
c. Air Delivery: Minimum 75 m³/min
d. Service Value: Minimum 1.65
e. Operating Voltage: 230V ±10%
f. Frequency: 50 Hz
g. Insulation Class: Class 155 (F-class) for safe and reliable operation
h. Bracket Fan should be marked with the manufacturer name, model number, rated voltage & Wattage

6. (D) AUTO VOLTAGE STABILIZER:

a. The stabilizer shall operate automatically and may be either block-based or servo-based (preferred). The type and size of the stabilizer shall be specified in the Employer's Requirements.
b. The winding material of the transformer core and all internal wiring shall have a minimum copper purity of 99.9%, with an allowable tolerance of ±0.1%. A copper purity test certificate from a government-approved laboratory must be provided.
c. A circuit breaker of appropriate rating (1.25 to 1.50 times of the input utility/grid current) shall be installed between the grid and the stabilizer for protection.
d. The stabilizer should automatically cut off the power if the grid or utility input voltage is ≥270V.
e. A three-pin plug and switch shall be installed on the output side of the stabilizer for operational convenience and safety.
f. The stabilizer must be compatible with a frequency range of 50 Hz to ensure proper functioning in local grid conditions.
g. The stabilizer shall maintain an efficiency of not less than 90% at any point when the input voltage is ≥ 120V.

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h. At input voltage of ≥120V, the stabilizer must be capable of running at 50% of its rated capacity (in Watts)
i. The stabilizer shall be capable of providing a regulated output voltage in the range of 210V to 250V when the input voltage is ≥120V.
j. The stabilizer must have digital Voltmeter for both input and output measurement.
k. The stabilizer must have the exhaust fan installed inside and shall have automatic temperature control through imbedded sensors.
l. The block-based stabilizer must have relays capable of handling voltage fluctuations, ensuring fast response times to protect the load, and shall feature high-quality contacts, thermal resistance, and best coil insulation.
m. The stabilizer may be equipped with LED indicators to display system faults and warnings for ease of monitoring and maintenance.

Note: The copper purity test from any accredited laboratory of Pakistan.

7. LED FLOOD LIGHTS:

a. Solar Based LEDs/Light fixtures shall conform to the latest IEC/ISO internationally recognized standards.
b. LEDs/Light fixtures should not be Chip-on-board (COB) single chip type due to their poor heat dissipation.
c. LEDs/Light fixtures shall be modular type with proper heat sinks.
d. Solar based lights (LED fixtures etc) should provide at least 120 Lumen/watt.
e. The Colour rendering Index (CRI) must be equal or greater than 70
f. LEDs/Light fixtures should be designed to deliver at least 10 years of service.
g. Complete lightening unit shall be weather proof (Protection Class IP67).
h. The output from the LEDs/Light fixtures should be constant throughout the duty cycle.

8. AC ENERGY EFFICIENT LED LIGHT BULBS:

a. Cap/Fitting/Base Type: E27
b. Colour Temperature: Cool White
c. Luminous Efficacy: Minimum 120 lumens per watt (L/W)
d. Lamp Life Time: ≥ 10,000 hours
e. Power Factor: ≥ 0.90
f. Rated Voltage: 220–230 Vac
g. Rated Power: 14 to 18 Watts
h. Must be NEECA certified.
i. LED Light Bulbs should be marked with the manufacturer name, model number, rated voltage & Wattage as per NEECA guidelines.

9. AC ENERGY EFFICIENT CEILING FANS:

a. Must have rated Power: 45 to 55 Watts
b. Sweep Size: 54" to 56"
c. Rated Voltage: 220–230 Vac (±10V)
d. Service value (m3/min/W): ≥ 4.5
e. Insulation Class: ≥ 155 (F-Class)
f. Noise Level: Should be within acceptable comfort levels
g. ±10% variation in power consumption is allowed as per PSQCA/NEECA standard
h. Motor Core: Made of electrical steel sheet
i. Winding Wire: 99.9% super enamelled copper CA wire or 99.9% pure copper wire
j. The fan must be energy-efficient and clearly marked with the manufacturer's model number, rated voltage, and wattage as per NEECA guide line.
k. Must be NEECA certified.

10. DC ENERGY EFFICIENT LED LIGHT BULBS:

a. The LED lamps must have luminous efficacy of at least 100 Lumens/Watt.
b. The LED lamp must be protected against reversed polarity of the operation voltage.
c. Base shall be an E-27 thread type.
d. The emitted light shall be cool or warm white.
e. The wide angle shall be between 120 degree to 125 degree.

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f. Operating Voltage 12Vdc / 24Vdc.
g. Lamps should be marked with the manufacturer model number, rated voltage, wattage and or batch number.

11. DC CEILING FANS:

Sweep	Rated Power	Speed	Operating Voltage
Inches	Watts (± 10%)	RPM	V
48"-56" (with Speed Control)	18-60 (W) BLDC	≥ 320 RPM	12 / 24 V

12. DC PEDESTAL FANS:

Sweep	Rated Power	Speed	Operating Voltage
Inches	Watts (± 10%)	RPM	V
≥ 18" Inch (with Speed Control)	18-60 (W)	≥ 1250 RPM (Full Speed)	12 / 24 V

13. INVERTER BASED SPLIT AC

Inverter based AC with both heating and cooling option.

S. No.	DESCRIPTION	UNIT	DETAILS
1	Split AC	EER	≥ 4 Star Energy efficient
2	Noise Level (Indoor)	Db (Max)	≤ 50
3	Voltage Range	Volts (Min & Max)	180 to 270 Vac

14. PVC CHANNEL DUCTS & PIPES

a. A product of good quality standard material from standardized firms/manufacturers with suitable size to be provided / used, as per direction / approval of Engineer In-charge.
b. Ducting must be done with proper steel nails/ screws and clips.
c. The PVC duct shall be flame retardant.
d. All ducting (wiring) must be aligned.

15. FLEXIBLE PVC PIPE

a. The flexible PVC pipe should be of good quality material from standardized firms/manufacturers with suitable size should be provided / used, as per direction / approval of Engineer In-charge.

16. CIVIL WORK:

The following Civil Works should be carried out for ground installation of SPV Modules/mounting structures.
a. Minor Cutting and clearing of trees/plantation to avoid shadows.
b. Civil work for earthing system as per the statutory requirements.

17. REFLECTIVE / INSULATING PAINT

The Roof Paint should be ultra-white, high reflective 100% acrylic elastomeric roof sealer designed for fixing leaks in roofs the paint should contain heat reflective pigments and additives that provide an excellent, highly protective barrier which reflects the sun's heat and destructive UV rays leaves a brilliant ultra-white finish, reducing surface heat absorption up 20°F.

The Reflective paint should comply with ASTM D6083, Fiber Reinforced for more protection, strength and durability which allows for contraction and expansion, Resists surface fungal growth.

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18. WARRANTY:

Three years Comprehensive Free Replacement, Repair and maintenance Warranty at site (Free of Cost) should be provided for all the components of Solar System. (if not mentioned separately otherwise)

18. (A) OPERATION AND MAINTENANCE MANUAL:

An Operation and Maintenance Manual, in English / Urdu language, should be prepared and provided by the contractor with the solar PV System. The Manual should have information about solar energy, photovoltaic, modules, DC/AC motor pump set, tracking system (if any), mounting structures, electronics and switches. It should also have clear instructions about mounting of PV module, DO's and DONT's and on regular maintenance and Trouble Shooting of the Solar System (Inverter etc). Name and address of the person or Centre to be contacted in case of failure or complaint should also be provided.

18. (B) STANDARDIZATION PRODUCTS:

a. Preference shall be given to standardized products approved by the C&W Department, provided they meet the minimum technical requirements outlined in the approved solar specifications.
b. Only products from the Original Manufacturer shall be accepted. The contractor shall submit authentic brochures/data sheets and valid certifications clearly indicating the name of the original manufacturer.

18. (C) EXCEPTIONS AND VARIATIONS:

Any exceptions or variations to the specified requirements must be explicitly declared by the Engineer In-Charge in accordance with Section 27 of the Khyber Pakhtunkhwa Public Procurement Regulatory Authority (KPPRA) Act, as amended. The scope, justification, and rationale for each exception or variation shall be clearly documented and supported by relevant data.

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B-SPECIFICATIONS FOR SOLAR PUMPING SYSTEMS

19. PUMP (SUBMERSIBLE):

Pump should be supplied having standard ISO-9906 specifications. The pump must be submersible, made of stainless steel. The characteristic curves (Original from Manufacturer) showing the efficiency at duty point and performance of the pump should be provided in the technical proposal and also at the time of pre-supply testing. The quoted pump should be tested for its performance and certified as per ISO-9906 standard. The pump should be suitable for installation and operation in tube wells/dug wells/open well with clear water discharge. Pump shall comprise of bowl assembly and non-return valve as integral part of pump's parts. Pump and motor shall rigidly couple through NEMA standard coupling. The stage casings of pumps should be connected as per NEMA/ANSI/AWWA /ASTM/BSS standard. Each stage casing must have replaceable wear ring. The impellers shall be secured to the pump shaft with tapered conical sleeves pressed into the taper bore of impeller or impeller secured through chrome plated stainless steel hexagonal sleeves. Suction casing must be between pump and motor with suction strainer as protection of pump against coarse impurities of the liquid handled.

Specification for main components of the Pumps:

S.NO	Components	Specifications
1	Casing/Diffuser	The Casing/Diffuser should be in fabricated stainless steel AISI 304 / 316.
2	Impellers	Stainless steel AISI 304 / 316.
3	Driving Shaft	Stainless steel 304/420 / 316
4	Sleeves	Stainless steel AISI 329/ 304 / 316
5	Gaskets	Rubber Gaskets
6	Bearings	AISI 329 stainless steel
7	Coupling & Screen + Cable Guard	Stainless steel AISI 316/319/304/420
8	Non-Return Valve	As per British standard specifications (BSS),
9	Pressure Gauge	N/A
10	Clamps	Steel – Pressed
11	Pump Efficiency	**Minimum efficiency of the pump (For discharge of more than 3000 iGPH) should be 70% ensured at duty point. (Duty Point of the Pump be preferably selected at the peak efficiency point or (Within ±20% of discharge) of Pump Peak efficiency Point)**

20. MOTOR:

The winding material should be 99.99% copper. The motor should have wet type, water cool rewindable/repairable stator. The motor should have non-disposable/non-hermetically sealed winding / High Efficiency Water Cooled Rewindable Permanent Magnet Synchronous motors can be supplied for enhanced efficiency and other added advantages. The insulation class of the winding material should be mentioned. For each model quoted, all the technical parameters such as rated voltage, power factor, efficiency, full load ampere, speed and other similar parameters should be provided at the time of pre-supply testing. The testing report with all basic parameters should also be provided at the time of pre-supply testing.

The motor shall be manufactured in compliance with National Electrical Manufacturer Association (NEMA) standards. The motor shall be three-phase submersible and shall be capable of operating at rated voltage of 380 - 415 Volts at 50 Hz - and 100 Hz in case of Permanent Magnet motor. (or as per VFD / Motor requirements). The motor should be capable of operating with variable speed through V/F control or Sensorless Vector Control. Winding of the motor shall of rewindable type with class – IC40 insulation and IP68 protection. The synchronous speed should be 2850-3000 RPM. Motor shall be capable of operating in well water with temperature normally start from 40°C. Motor should be designed for continuous operation. Motor must be filled with water without any chemical additive's hazards to health for cooling. The motor must be properly protected against the entry of well water sand etc by double mechanical seal one is rotating and other

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stationary and must be made of Silicon carbide/ Tungsten carbide and must be protected with sand protection guards. All supports shall be high grade cast iron and stator outer side jacket body should be in stainless steel in AISI 304. The excessive pressure due to heating up of the filled water must be compensated by a pressure equalizing rubber diaphragm in the lower part of the motor. The axial thrust of the pump shall be countered by oscillating sliding block type thrust bearing. The thrust bearing of the motor should be able to bear a downward thrust force from the water pump and the upward thrust force produced while starting the water pump. Motor in open well / water tank should be installed with cooling jacket / shroud / sleeve and when motor is installed in bore then installing of cooling jacket is also required.

Technical specification of rewind-able wet stators, three phase squirrel cage water filled submersible motor.

S. No	Components	Specification
1.	Winding	Made of pure electrolyte copper and the winding insulation should be suitable for > 1000 Volts and must full fill resistant tests range.
2.	Stator	Energy efficient low-losses electrical magnetic sheet M800 or superior should be fixed in stainless steel casing. M800 or M600 magnetic sheet are preferable to use.
3.	Rotor	Energy efficient low-losses electrical magnetic sheet M800 or superior fixed with high grade copper bars or High-Grade Neodymium (or equivalent or better) Permanent Magnets in case of Permanent Magnet motor.
4.	Spline Shaft	AISI 420 stainless steel, flange dimension according to NEMA standard, over size design to ensure stiffness in severs condition.
5.	Shaft bearing	Water lubricated guide/general bearings fixed in upper and lower brackets should be made of metal impregnated carbon.
6.	Lower thrust bearing	Thrust sliding block bearings, self-aligning Mitchell type, should be able withstand **15500/20000N** axial load.
7.	Mechanical Seal (Stationary & Rotary	Silicon carbide or tungsten carbide mechanical seal.
8.	Cooling filling fluid	Water mixed with non-toxic anti-freeze provide cooling and lubrication also protect and prevent inside parts from corrosion.
9.	Degree of protection	IP68
10.	Insulation Class	Insulation Class B (130°C) NEMA Insulation Class F (155°C) NEMA or above Will be given Preference.
11.	Voltage Tolerance	+6% to -10%
12.	Mounting position	Capable of both Vertical or horizontal Installation
13.	Class	IC40
14.	Maximum Immersion	150 Meters
15.	Starting per hour	Motor shall be capable of 10 starts in an hour.
16.	Motor Efficiency	Efficiency of motors 7.5 HP and above should not be less than 75% at Full Load and Motor Rated Voltage.

21. SUBMERSIBLE FLATE ELECTRIC CABLE (4-Core):

The Submersible cable (4-Core) should be made of 99.9% copper strands with double PVC insulation for **1000Vac**, should be adequately flexible and environment friendly. Stranded and flexible insulated copper wires and cables must be used for all outdoor and indoor installations. The wiring that leads into the building shall be protected in a conduit. The cable must have undergone quality tests as per BSS standards. Cable size should be selected so that the Voltage drop Losses in the drop cable should not be more than 2.5%.

Refer to Table-02 For Cable Sizing.

Following lab tests are mandatory.

- Conductor resistance test.
- Insulation resistance test.

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- Pressure test.
- Spark test.
- Note: The Supplier should provide the quality tests certificates at the time of pre-supply testing and inspection.

22. COLUMN PIPE:

The column pipe shall be flanged ERW steel pipes confirming to ASTM designation A-53 with a minimum thickness of **3.6 / 4.0 mm (3.6 mm for pipes up to 2.5" dia and 4 mm for pipes above 2.5")** and shall be painted with corrosion resistance paint of suitable thickness. Flanges thickness of 19-20 mm shall have grooves for cable passage. Each column pipe shall be complete with gaskets, bolts/studs, washers and nuts. All nuts, bolts, and washers shall be made of minimum A2 grade stainless steel.

The column pipe shall be supplied in interchangeable section having an approximate length of 10 feet column pipe shall be flanged perpendicular to the axis of pipe.
Column pipe size should be selected so that the Head Losses in the column pipe should not be more than 5%.
HDPE Pipe of ≥ 0.75 Inch diameter, SDR 13.6, PE100, conforming to ASTM F-2160 Standard without Joints to be installed/included along with and equal to Column pipe for confirming Water Level testing purpose.

FEATURES:

- Manufacturer's pipes should meet international standards like BSEN 10255 & ASTMA 53.
- Dimensional accuracy circularity and plan end cut should be observed,
- Weld strength of pipe and mechanical properties or raw material should be tested as per manufacturing standards.
- Pipes should be NDT tested (Non-destructive – Eddy current)
- Pipes should be hydrostatically pressure as per manufacturing standard.
- Pipes should be gone through straightening process to remove bendiness.

TABLE-01: COLUMN PIPE SIZE WITH MAXIMUM DISCHARGE.

Column Pipe Diameter (Inch/mm)	TYPE	COLUMN PIPE DIMENSIONS (Minimum)	MAX DISCHARGE ALLOWED	
			Litres / Hour	iGPH
25 mm	HDPE	PN12 / SDR 13.6 / PE100	1,300	286
32 mm	HDPE	PN12 / SDR 13.6 / PE100	2,300	506
40 mm	HDPE	PN12 / SDR 13.6 / PE100	4,650	1,023
50 mm	HDPE	PN12 / SDR 13.6 / PE100	8,250	1,815
2"	MS	3.6 / 4 MM Thickness	12,000	2,640
2.5"	MS	3.6 / 4 MM Thickness	21,000	4,619
3"	MS	≥ 4 MM Thickness	33,500	7,369
4"	MS	≥ 4 MM Thickness	70,000	15,398
5"	MS	≥ 4 MM Thickness	124,000	27,276
6"	MS	≥ 4 MM Thickness	200,000	43,994

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23. TOPSET:

Top set shall comprise of Bore covers plate, (covering bore hole completely and securely), installation/suspension clamps (2-Nos), Sluice Valve (BSS/ASTM), Reflex Valve (BSS/ASTM), Washout Valve approx. 3-4 feet above the ground (T-Connection For Testing Pump's discharge), connector and cable jointing material (Cable connection from motor to switching device shall be joint free), Liquid Filled Pressure gauge minimum 4 Inch diameter suitable / appropriate for the required head pressure and cable ties. Bore Cover Plate should have provision for water level testing facility (i.e.: Hole for Sonic Water Level Meter / HDPE Pipe insertion).

- **Non-Return Valve / Sluice Valve**
  As per British standard specifications (BSS), Minimum PN16 (16 Bar) or above (As per Site Requirements). PN Value / Bar Capacity of Valves must be more than Installed Pump Max/Shut-off Head minus Static Water Level of Bore. (Leakages in Valves are NOT acceptable).

- **Pressure Gauge**
  As per British standard specifications (BSS), having PSI or Bar scale (4 Inch Size), Liquid Filled, minimum 500 PSI Range or Above (As per Site Requirement), Looped Siphon tube Pipe, Stainless Steel/polypropylene Casing.

For Cleaning of solar Panels, Plastic pressure pipe should be provided of suitable length to reach the furthest / last Solar Panel.

Every Water Supply Scheme should have a non-removable name plate fitted at suitable place / box having essential information and bearing the name of supplier, Consultant and client.

24. SOLAR PUMP INVERTER / CONTROLLER:

a. The solar pump inverter/controller should have built-in advance version of Auto MPPT controller, over load protection, soft start/Soft Stop Features and Variable Frequency Drive (VFD) with integrated Gate Bipolar Transistors (IGBTs) of European, USA or Japanese origin or at least equivalent.
b. The make and origin of the inverter/controller should be clearly mentioned in the catalogue and submitted in the technical proposal.
c. The inverter offered should comply to or Equivalent standards:
   i. CE/RoHS
   ii. Low Voltage Directive 2014/35/EU
   iii. EMC Directive 2014/30/EU
   iv. IEC 62109-1 (Safety of Power Converters for use in PV Systems)
d. The complete datasheet showing all the electrical parameters like input & output voltage ranges should be provided in the technical bid.
e. All the electrical parameters like input & output voltage ranges, and efficiency should be provided at the time of pre-supply testing and inspection.
f. Efficiency of inverter should be 96% and above at Rated Capacity.
g. Efficiency of MPPT should be 98% and above.
h. The inverter < 25kW ingress protection of inverter must be minimum IP 65 Rating or above and for inverter ≥ 25kW ingress protection of inverter / enclosure will be minimum IP 54 Rating or above.
i. Inverter / Controller having the capability to run both on AC and DC Power would be given preference.
j. Inverter should have at least three (3) years product and performance warranty.
k. The Pump Controller/Inverter should have an ON/OFF Switch/Button to Start and Stop the Pump.
l. Inverter should have active RS232/485 etc communication port available, the Data available through this port can be used for Remote Monitoring.
m. Inverter circuit must include protection against:
   i. Over or Low voltages and currents beyond critical level of the inverter's circuits.
   ii. Protection against accidental short circuits & reverse polarity connections.
   iii. Protection against lightning induced transients.
   iv. Over load protection.

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v. Low RPM Protection (i.e.: Frequency < 30 Hz or as per pump characteristic curve) Motor Should Stop.
vi. Dry run protection. (PF / Current Based).

n. In case of Permanent Magnet Motor. The inverter shall be capable of operating motors through V/F Control and sensor-less vector speed/ torque control; and shall have the feature of auto-learning necessary motor parameters.

25. dV/dT or Sine Filters with Inverter (VFD):

a. The use of load reactors (dV/dT Filter) increases the reliability, performance, and efficiency of VFD systems, extends the life of both drives and motors, and reduces the amount of energy consumed by the motor/drive system.
b. Output dV/dT or Sine Filters (between VFD and Motor) of appropriate size (for 3-phase ≥380Vac Motor of Class ≤ B Insulation) should be used where the cable length between motor and inverter is more than Fifty (50) Feet or as advised / recommended by the inverter manufacturer in their Technical Documentation. For Cable lengths of more than 150 meters sine filters should be used.
c. Filter should be enclosed in a vented box.
d. Filter Efficiency should be minimum 97%.
e. Filter should have a current rating of equal or greater than Motor FLA Rated Current.
f. Distance between filter and pumping inverter should not be more than 2 meters.
g. Motors with Insulation Class F, H or above are exempted from the requirement of dV/dT Filter.

26. SYSTEM DESIGN FOR PUMPING SYSTEM:

a. Suitable factor of safety should be applied while designing the system in order to have compensations for variations in irradiations.
b. For Fixed Structure, the PV panel **peak power at STC (Wp) should be 75% more** than the Motor basic input power **(PV Loss Compensation Factor = 1.75)**.
c. For Auto / Manual Tracker, the PV panel **peak power at STC (Wp) should be 50% more** than the Motor basic input power **(PV Loss Compensation Factor = 1.5)** or as per approval of Engineer In charge.
d. If Single Axis Auto Tracker Structure is installed on the above factor, then daily operational timings of pumping can be increased by 10-20%, as compared to fixed structure installation.

e. Total PV Power (Wp) (Imperial Gallons) = $\frac{\mathbf{Q\ (iGPH)} * \text{TDH (ft)} * 746 * \text{PV Loss Factor}}{60 * 3300 * \eta_{pump} * \eta_{motor}}$

f. Total PV Power (Wp) (US-Gallons) = $\frac{\mathbf{Q\ (US\text{-}GPH)} * \text{TDH (ft)} * 746 * \text{PV Loss Factor}}{60 * 3960 * \eta_{pump} * \eta_{motor}}$

g. Total PV Power (Wp) (Metric Units) = $\frac{\mathbf{Q\ (m^3/hr)} * \text{TDH (m)} * 9.81 * 1000 * \text{PV Loss Factor}}{3600 * \eta_{pump} * \eta_{motor}}$

h. Voltage (V_{mp}) of Each String of PV Panels should be as per details given below and String Voltage (V_{mp}) should be within the MPPT range of Inverter.
   i. For 380 V_{ac} 3-Phase Motor = 380 * 1.414 * 1.06 = 570 Vdc String, minimum
   ii. For 220 Vac 3-Phase Motor = 220 * 1.414 = 310 Vdc String.
   iii. Small Inverters (i.e: 3-Phase, 220 Vac) with voltage boost function and DC Motors are exempted from the above string voltage requirements. String can made as per boost Inverter / Controller recommended String DC Voltage and should not be less than 240Vdc in any case.

i. Details of each PV Panel string should be submitted in technical proposal (i.e: Nos of total strings and Nos of PV panels in each string along with wattage and V_{mp} of each PV panel).
j. Unjustified Oversizing in PV Panels Wattage is not allowed.
k. To avoid any oversizing, all commercially available PV Panels should be considered.
l. Solar Pump Inverter should have a kW capacity equal or greater than the Motor Rated Input Power.
m. Solar Pump Inverter / Controller Size (kW) ≥ (Motor Rated Power in kW / Motor Efficiency).

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n. Solar Pump Inverter / Controller should have a current rating of 1.15 Times (minimum) of Motor FLA Rated Current.
o. Motor should not be loaded more than 90%. (i.e: Design / Calculated BHP should not be more than 90% of Motor Rated Horse Power)
p. Along with this specification, contractors should also satisfy manufacturer's recommendations for all major components of Solar Pumping System.
q. Requirement of Efficiency for Motor i.e. 75% will not apply on Motors smaller than or equal to 5.5HP and the requirement of efficiency for pump i.e. 70% will not apply on pumps having discharge equal to or lower than 3000 GPH.

27. PRESSURE PUMPS (UP TO 5.5 HP):

a. Submersible pump confirming to ISO-9906 Standard.
b. Pump + AC Motor (3-Phase-220V/380V) or DC Motor and Pump with Display Unit.
c. Solar pump inverter/controller should be MPPT based and Minimum Ingress Protection of IP65.
d. In case, where the column pipe diameter is less than or equal to 50 mm (For discharge equal or less than 8250 LPH and/or for Motor 5.5 HP and below), HDPE pipe of at least PN12 / SDR 13.6 / PE100 (For TDH of equal or less than 300 ft) without joint may be used instead of MS pipe for better economics and to avoid hydraulic losses. However stainless-steel rope of minimum diameter of 6 mm (28 mm^2) for suspension of pump-set must be supplied with HDPE pipe. (Note: For TDH of more than 300 ft, HDPE Pipe type / thickness may be increased/changed accordingly)
e. Top set shall comprise of Suitable Galvanized stand (Design should be verified from Engineer In-Charge before start of work)
f. deleted
g. Connection to overhead water storage tank. Top bend, S.S Fasteners & Erection clamps.
h. Civil work to protect borehole i/e foundation.
i. The pump should operate safely with Sand particles up to (50) gram/m^3.

28. DC SOLAR WATER PUMP-SETS (UP TO 5.5 HP)

a. DC Motor can also be provided for Equal or less than 5.5 HP.
b. Motor should be capable of both AC and DC operation. There must be auto power source recognition feature.
c. The motor should be brushless (BLDC), permanent magnet type.
d. The Controller must have a display Unit, showing all essential parameters (i.e: Current, Voltage etc).
e. The Controller must be of MPPT type. MPPT efficiency should be equal or more than 98%
f. Pump should have auto and soft start / stop feature.
g. The pump-set should have following protections
    1. Dry Running Protection
    2. Reverse Polarity Protection
    3. Over phase protection
    4. Over Head Protection
    5. Lose Phase Protection
    6. Electronic Protection
    7. Over Current/ Overload Protection

29. SOLAR AUTO TRACKER:

a. The solar tracker offered should be fully automatic and intelligent, and must be capable of Single axis tracking (from east to West) and should have its own power supply (PV Panel, Battery and Charge Controllers) other than PV Panel used for Pumping Setup.
b. Individual Auto-Tracker should be ≥ 6 kW each and Tracking Accuracy should be within ± 5°.
c. The auto Tracker should also have manual control mode to adjust the tracking angle manually. All Structure Material Should be Hot Dipped Galvanized Steel (Minimum 80 Microns).

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c. The auto Tracker should also have manual control mode to adjust the tracking angle manually. All Structure Material Should be Hot Dipped Galvanized Steel (Minimum 80 Microns) or epoxy coating with red oxide (as per direction of Engineer incharge).
d. All nuts, bolts, washers and other fasteners for mounting structure shall be made of minimum A2 grade stainless steel.
e. Foundation and other details will be separately provided.
f. Three years Comprehensive Free Replacement, Repair and maintenance Warranty (Free of Cost) should be provided for all the components of auto Tracker (including Batteries).

30. PV MOUNTING FRAME WITH MANUAL TRACKING:

a. Suitable for Up to 6.5 KW PV Panels easily movable in multi directions having flanges with bearing balls 7/16" and having angle adjustment.
b. Base steel cage 7/8", MS rod 3.5 feet length with nut-bolts system for strong anchoring.
c. Pillar pipe 5 mm with 6" dia, base plate 15"x15"x16mm size with 04 numbers of supports.
d. Support for PV, 4mm thickness 5" dia pipe and 24"x6$^{1/2}$"x1/4" side plates.
e. MS I Beam/Garder side bracing 3"x7"x1/8". C Channel frame 3"x1½"x1/8" for panel mounting.
f. Steel structures/frames shall be enamelled paint with lead oxide.
g. Galvanized nuts, bolts and washers for tracker fitting.
h. Steel frame shall be properly designed and shall withstand wind speed/load of at least 130km/hr and tough weather condition.

31. PRE-SUPPLY TESTING & INSPECTION:

The firm applying for the tender has to provide the recent test bed reports from the pump/motor manufacturer or any other third party as per ISO-9906 standard. Each of the offered pump set models must undergo these tests prior to supply and installation, in order to ensure the quality and standard of the equipment contractor may be asked to provide test result conducted by third party for re-verification.

32. (Deleted As repetition of Section A, serial 18 (A))

33. GRID TIE INVERTER (ON-GRID WITHOUT BATTERY BACKUP / HYBRID WITH BATTERY BACKUP)

1. UL-1741 Certified or IEC 62109-1 and IEC 62109-2 or Equivalent Certificates.
2. Minimum 95% Conversion Efficiency at Rated Capacity (High Frequency Inverters).
3. Minimum 87% Efficiency for Transformer based inverters (Low frequency Inverters).
4. The inverter should have built-in MPPT controller.
5. The Priority of the inverter should be set that load will be running from the solar energy then Grid and, in the end, will be running from the Battery Backup.
6. Inverter (Hybrid Only) must be capable of configuring for Charging GEL, Lead Carbon, OPzV/OPzS Batteries and Lithium Iron Phosphate batteries (LiFePO4).
7. Hybrid Inverter (If quoted along with Lithium Batteries) may be capable of communication with the BMS of Lithium Batteries.
8. Rated output voltage of inverter / Controller shall be pure sine wave AC.
9. Total harmonic distortion (THD) in AC output should not exceed 3% at rated capacity.
10. The degree of protection of the inverter Installation should be IP-65 or above.
11. Wide input voltage range capability. (i.e.: Voltage Range can be adjustable / selectable)
12. Natural convection cooling for maximum reliability
13. Outdoor enclosure for unrestricted use under any environmental conditions
14. Capability to connect external sensors for monitoring environmental conditions.
15. The output of the inverter must synchronize automatically its AC output to the exact AC voltage and frequency of the grid.
16. The Inverter should have the capability of Parallel operation up to three units. (Only For projects, where more than one inverter should be installed).
17. Inverter should have active CAN/RS485/RS232 or equivalent etc communication port, the Data available through this port can be used for Remote Monitoring.
18. Liquid crystal display should at least be provided on the inverters front panel or on separate data logging/display device to display following
    a. DC Input Voltage
    b. DC Input current
    c. AC Power output (kW)
    d. Current time and date
    e. Temperatures (C)
    f. Converter status
19. Inverter circuit must include protection against:
    - Over or Low voltages and currents beyond critical level of the inverter's circuits.
    - Protection against accidental short circuits.
    - Protection against lightning induced transients.
    - Over load protection.
20. The Maximum power point tracking MPPT efficiency ≥ 99%, and converter efficiency up to 98% of MPPT charge controller.
21. The inverter shall be equipped with certified anti-islanding protection in compliance with international standards (e.g., IEEE 1547, IEC 62116), to ensure immediate disconnection from the grid during outages or abnormal grid conditions.

34. OFF-GRID / HYBRID INVERTER:

1. The Inverter must be pure sine wave output suitable for 220 Volt, 50 Hz.
2. Inverter must be capable of configuring for Charging GEL, Lead Carbon, OPzV/OPzS Batteries and Lithium Iron Phosphate batteries (LiFePO4) (If Applicable).
3. The Inverter / system must have a MPPT Solar Charge Controller.

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4. Minimum 92% Conversion Efficiency at Rated Capacity (High Frequency Inverters).
5. Minimum 87% Efficiency for Transformer based inverters (Low frequency Inverters).
6. Total harmonic distortion (THD) in AC output should not exceed 3% at rated capacity.
7. The inverter must be user programmable for selecting PV, Grid and Battery Priority as well as Built-in programmed and user defined voltage and current settings of the charge controller for GEL, Lead Carbon, OPzV/OPzS batteries and Lithium Iron Phosphate batteries (LiFePO4).
8. The Inverter must have Protective function limits for:
   a. AC under voltage protection
   b. AC over voltage protection
   c. Battery under voltage Alarm
   d. Low Voltage Disconnect
   e. High Voltage Disconnect
   f. Overload and Short Circuit Protection
   g. Over Temperature Protection
9. The inverter must be ISO 9001, ISO 14001 and CE Certified.
10. The inverter must have IEC 62109-0 1 and IEC 62109-2, or Equivalent Certificates.
11. The degree of protection of the inverter Installation should be IP-65 or above.
12. Wide input voltage range operation capability. (i.e.: at least 170 V to 270V for Operation)
13. Inverter should have active CAN/RS485/RS232 or equivalent etc. communication port, the Data available through this port can be used for Remote Monitoring.
14. Inverter (If quoted along with Lithium Batteries) must be capable of communication with the BMS of Lithium Batteries.
15. Inverter settings be preferably password protected.
16. Inverter should be capable of battery less operation (preferred or as per BoQ requirement).
17. Discharge Current should be preferably programmable (i.e.: discharge battery Current can be limited to user desired values).
18. The Maximum power point tracking MPPT efficiency ≥ 99%, and converter efficiency up to 96% of MPPT charge controller.

Note:

The THD (Total Harmonic Distortion), inverter capacity and efficiency may be conducted from the accredited laboratory in Pakistan.

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D-SPECIFICATIONS FOR SOLAR STREET LIGHTS

35. SOLAR STREET / ROAD LIGHT SYSTEM DESIGN:

a. The assessment of Wattage of the LED Luminaire, Pole Height, Pole thickness, Pole top diameter, Pole base diameter, Base plate size, Base Plate thickness, Stiffener size, Stiffener thickness, Pole arm design, Pole Arm Length, Pole arm thickness, Pole arm diameter, Pole arm Placement / Fixing position, RCC foundation size, Anchor / J-bolt size, Steel Rebars cage (Mesh) and Number of Poles (Pole to Pole distances), should be according to the design provided / approved by the Engineer In-charge.
b. Round Conical or Octagonal Hot Dipped Galvanized Pole of average 80 Microns should be installed.
c. All Nuts, Bolts and Washers should be stainless steel.
d. Pole base plate should be tightened in between two stainless steel nuts and washers (one nut and washer at upper and one nut and washer at lower side of the base plate).
e. All Anchor / J-bolt shall be in level and align to each other.
f. All Anchor / J-bolt shall be galvanized.
g. All Anchor / J-bolt shall have at least 150 mm minimum threads.
h. All poles shall be installed on levelling nuts secured to the anchor bolts and with locking nuts on the top of the base flange.
i. The concrete ratio should be 1:2:4 for RCC foundation.
j. Proper sketches of Pole, base plate, RCC Foundation and Steel Rebars cage (Mesh) should be provided and approved from Engineer In-charge.
k. In order to focus on winter sun availability and Easy cleaning of Solar panel from dust etc with Rain water, Solar Panels should be installed at 180° Azimuth Angle and the Tilt angle (slope) of PV Module should be between 45°±5° (Only for Solar Street Lights).

36. LED SOLAR ROAD/STREET LIGHT FIXTURE:

1. LED Efficacy must be greater than or equal to 130 Lumens/Watt.
2. The fixture must be IP-66 Rated or above.
3. The Colour temperature of the LED should be Pure white in the range of 5000-6000 K.
4. The LED Light distribution must be IESNA Type-II
5. The LED must be suitable for working Temperature from -40 ~ + 60°C with relative humidity of 15% ~ 90%
6. The Colour rendering Index (CRI) must be equal or greater than 70.
7. The LED Light Fixture must be LM79 and LM80 Tested.
8. LEDs/Light fixtures should not be Chip-on-board (COB) single chip type due to their poor heat dissipation.
9. LEDs/Light fixtures shall be modular type with proper heat sinks.
10. The output from the LEDs/Light fixtures should be constant throughout the duty cycle
11. LED Life should be greater or equal to than 50,000 Hours.
12. The LED Light Fixture must have the following certification:
    - ISO 9001
    - ISO 14001
    - CE (EMC and LVD) Certified or equivalent.
    - International standard Certifications

Note: Product Brochure, Catalogue and certificates must be attached with the Technical Bid

37. SOLAR CHARGE CONTROLLER (FOR STREET / ROAD LIGHTS):

a. The charge controller must be suitable for the required battery voltage, auto voltage recognition feature and capable of charging Flooded, GEL, AGM, OPzV, OPzS & Lithium Ferrous Phosphate (LiFePO4) Batteries.
b. The charge controller must be IP-67 rated or above for outdoor installation

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c. The charge controller must be Remote Controlled for parameter setting. The system must have the following feature:
   - Remote Parameter Setting and Monitoring
   - Remote control of the Lights (on/off, timer setting etc)

d. The charge controller must have MPPT Technology and Automatic Battery Voltage Recognition.
e. The charge controller must have at-least three stage Flexible dimming function (0-100%).
f. The Maximum power point tracking MPPT efficiency ≥ 99.0%, and converter efficiency up to 98%
g. It must have temperature compensation for charging batteries in higher temperatures.
h. Charge controller must have the following protections:
   - PV Short circuit
   - PV reverse polarity
   - PV over voltage
   - PV over current
   - Battery over charging
   - Battery over discharging
   - Battery reverse polarity protection
   - Load short circuit
   - Load overload protections

i. It must have proper heat sink to dissipate excessive heat
j. The charge controller must have protection for reverse flow of current through the PV modules
k. Controller should have active port for GSM based communication for Remote Monitoring.
l. Mid Night based timing controller will be preferred.
m. The Solar Charge controller must have the following certification:
   - ISO 9001
   - CE Certified

Note: Product Brochure, Catalogue and certificates must be attached with the Technical Bid

38. <u>Battery and Controller Box:</u>

a. The battery box should be made of Hot Dipped Galvanized Sheet of average 80 Microns.
b. Stand deleted.
c. For Pole Mounted batteries Battery boxes must be made of minimum 16 SWG sheet and must have proper locking arrangement for protection against theft.
d. For underground battery installation, the battery box should be made of minimum 16 SWG sheet and should be properly sealed to ensure protection against water. Proper cable glands and packing material should be used to ensure water proofing of the box.
e. The battery and Controller Box should be at least IP65 ingress protection.

39. (Deleted As repetition of Section A (2)).

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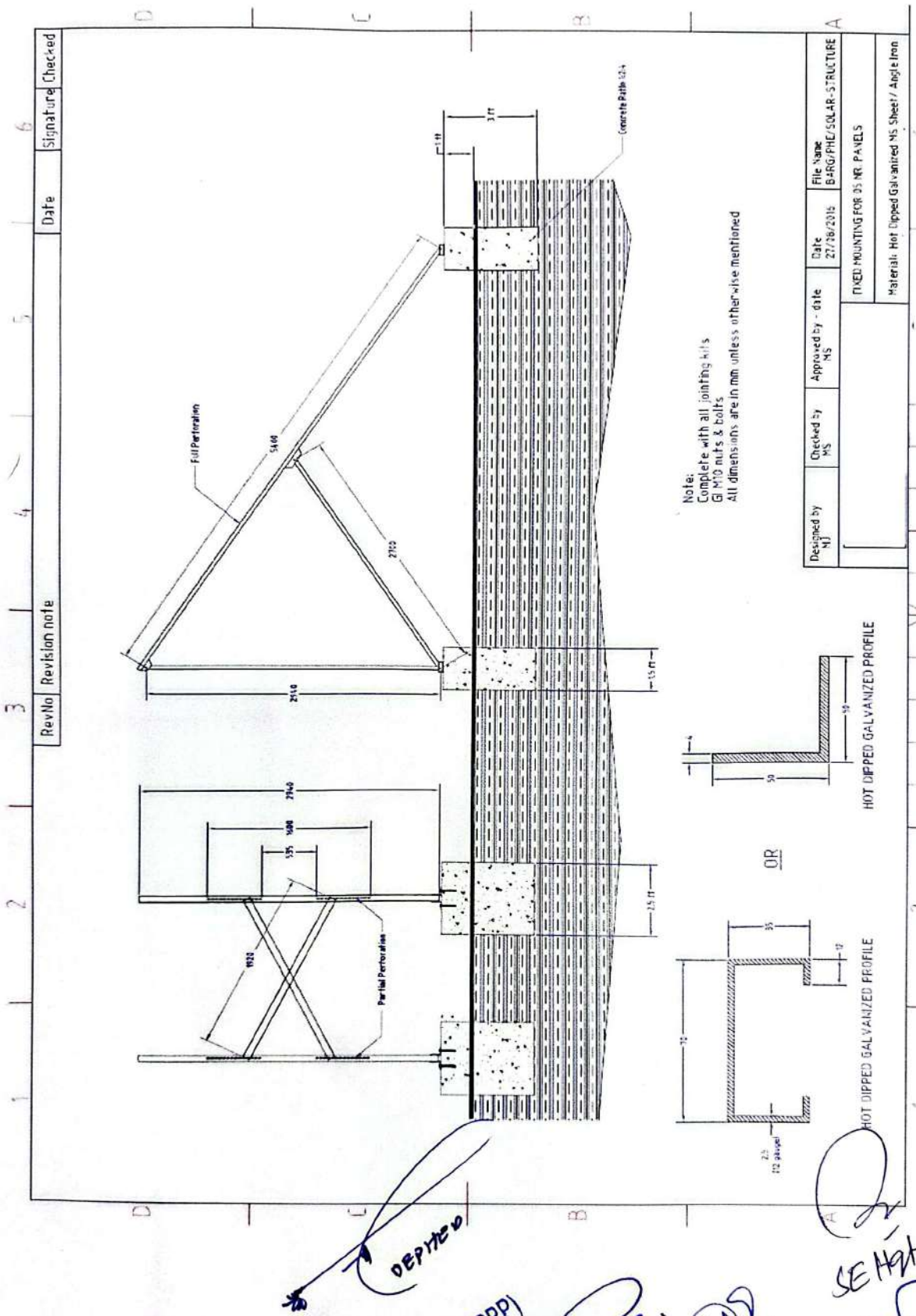
APPENDIX-I
(STRUCTURE DRAWING)



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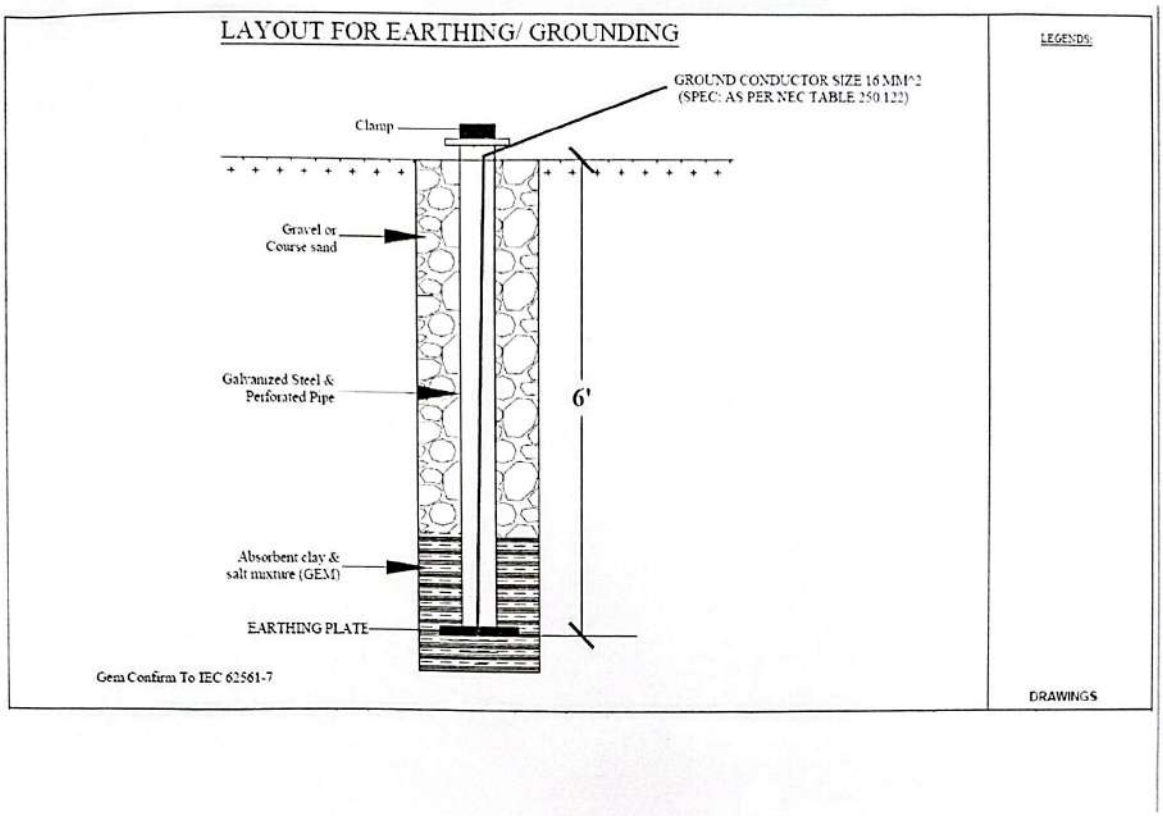
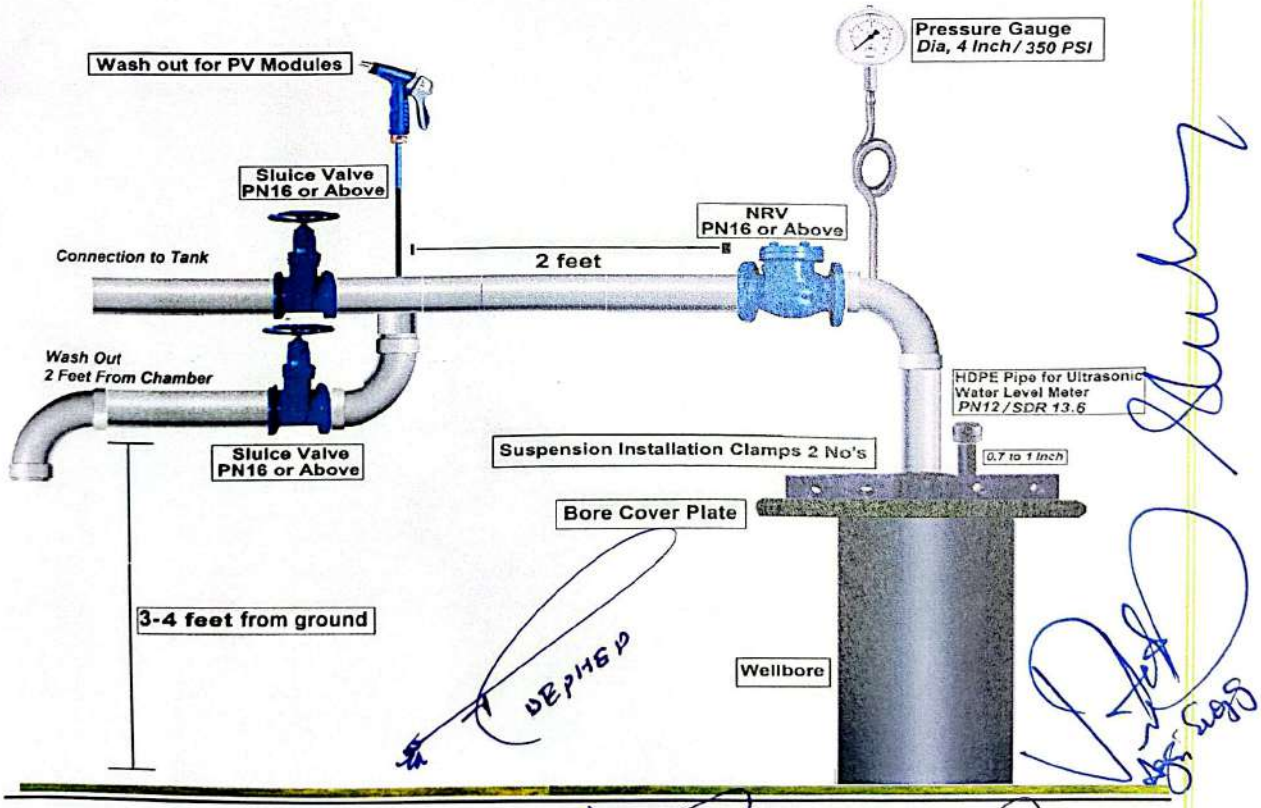
APPENDIX-II
(EARTHING / GROUNDING DRAWING)



APPENDIX-III TOPSET LAYOUT:



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APPENDIX-IV
(SYSTEM SINGLE LINE DIAGRAM-PUMPING)

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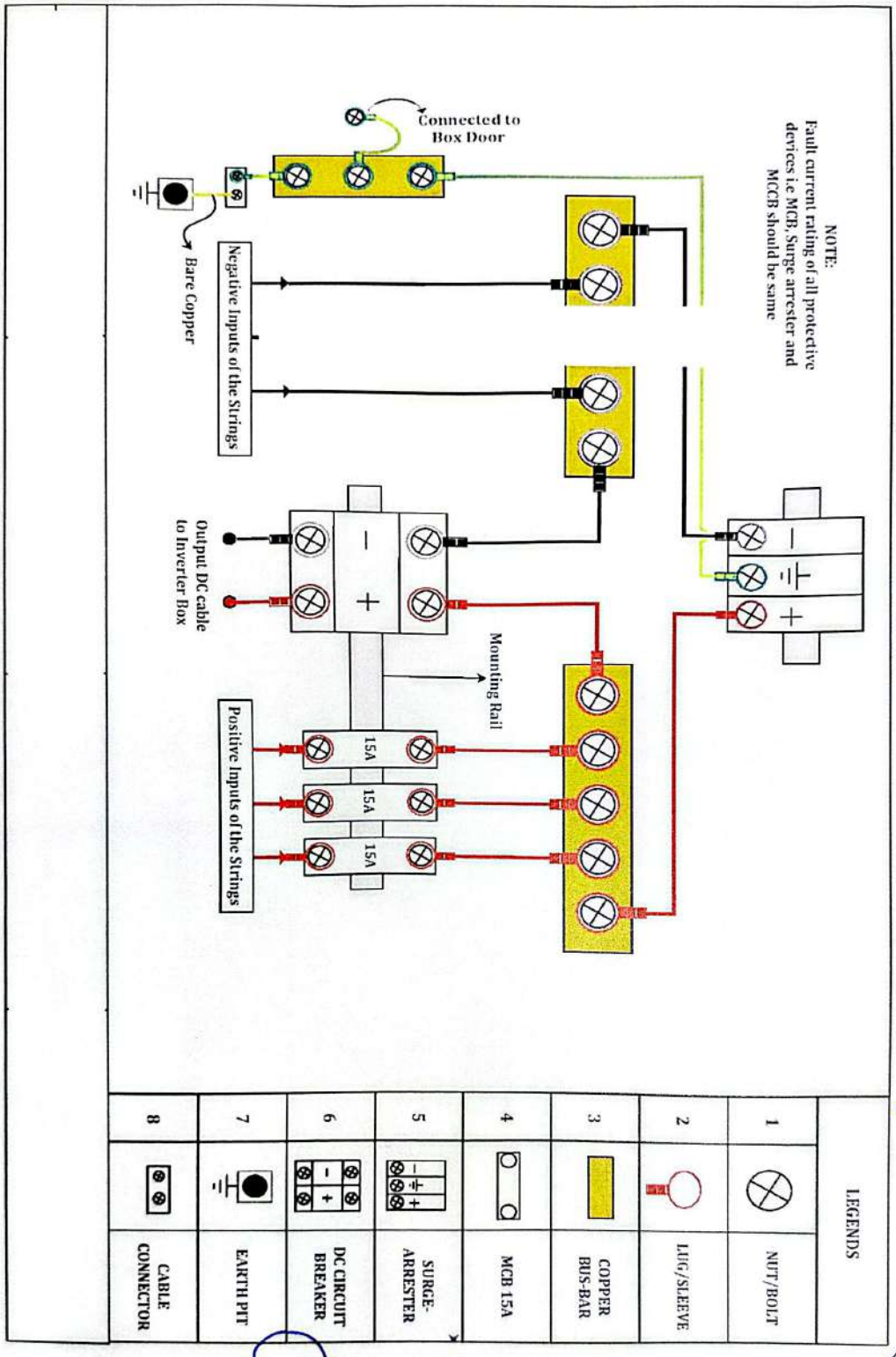
APPENDIX-V
(JUNCTION/COMBINER BOX SCHEMATICS DIAGRAM)



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MINIMUM SIZE OF BONDING/EQUIPMENT GROUNDING/GROUNDING ELECTRODE CONDUCTORS AND GROUND BUS

Table 250.122 Minumum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Copper	Aluminum or Copper-Clad Aluminum
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	800
5000	700	1200
6000	800	1200
	Size (AWG or kcmil)	

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