



Scope of Work and Technical Specifications Supply and Installation of Solar PV Systems for Water Pumping Station (in Amyoun) in Lebanon

1. INTRODUCTION

1.1. Background Information

The Norwegian Church AID **NCA** vision is to help the local communities to cover their needs for water with less cost and lower environmental impact in terms of CO2 footprint and emissions. Installing a PV system to supply the water pump would help reduce the use of the generator and hence the cost of the fuel and the produced emissions. NCA is coordinating with the local municipalities to help them serve their communities by providing the finance and technical support for solar pumping system . In our case ,

The project involves the installation PV solar generators on a plot of land currently used as a parking for a school in Amyoun that has given the permission for the municipality to install the PV system on it to supply a near by well pump (under the jurisdiction of North Water Establishment) located in the Village of Bechmezzine but supplying the village of Amyoun.

2. SCOPE OF WORKS

The works under this Project consist of supplying, installing, testing, commissioning, handing over in good operating conditions complete Solar PV Systems, documentation, training, and Defects Notification Period- DNP over a period of one year.

The Contractor shall provide all necessary components, accessories as well as manpower, scaffolding, civil works, machines, tools, instruments, etc at the Contractor's own expense to install complete operational devices.

The equipment furnished to these specifications must meet or exceed all requirements herein. Modifications of or additions to basic standard equipment of less size or capability to meet these requirements will not be acceptable. All Materials and equipment shall be subject to the approval of the Employer.

The Contractor shall be responsible for providing all Engineering, Procurement and Construction works for the optimal design and operation of the plant, including but not limited to:

Verification of the Design Drawings and modification in case of discrepancy between these drawings and the site conditions, in full coordination with the Project Team.

- Site preparation (clearing, pruning, excavation, etc).
- All planning, application and obtaining construction permits from authorities for the Solar PV Systems (Including but not limited to, the Lebanese Center for Energy Conservation- LCEC,

Ministry of Interior and Municipalities, any other pertinent entities, etc..) required for the construction and realisation of the project.

- Testing and checking the well pump prior to starting the project to verify the duty point head and flow in the water pumping station site.
- Supply and installation of solar PV modules of a proven PV technology from a reputable manufacturer.
- Supply and installation of support structures for the photovoltaic modules, inverters, Variable Frequency Drive, Filters Solar PV hybrid controllers, Electric panels, etc.
- Supply and installation of PLC controllers, weather stations where required.
- Construction of a new control room for the electrical and control panels.
- Supply and installation of elements needed to secure modules on the structures.
- Supply, installation, and connection of all electrical panels required in the DC and AC side, including protection devices.
- Supply and installation of all cabling and electrical connections between the elements of the PV system, including the electrical conduits and raceways/cable trays (embedded and surface mounted) for cable routing and trenches.
- Supply, installation, and connection of inverters for connection to the local electrical network capable of providing reactive power, including DC and AC protections.
- Supply, installation, and connection of remote monitoring systems (central acquisition and data processing, meteorological station), and a local 50-inch screen display.
- Supply, installation, and connection of a UPS system (Including Batteries) for control equipment.
- Supply, installation, and connection of complete interface systems between different blocks of the same facility (Water Pumping Station) if necessary.
- Supply and installation of equipotential bonding devices and grounding system of all metal parts of plant.
- Trees trimming where needed subject to the discretion of the NCA Project Team.
- All concrete bases, foundation, and civil works necessary for the support of the system.
- Supply and installation of car park sheds.
- Transport of all equipment to the site, on site temporary storage and security and replacement of all equipment in case of breakage.
- The Contractor shall locate in coordination with the Beneficiary's representative(s), if needed, an area to store the materials. The Contractor shall maintain a good level of coordination with the NCA Project Team and the Beneficiary's representative(s) to ensure smooth implementation of

the fieldwork. The Contractor must store the goods in a safe place that is not exposed to any external factors that may harm it, and shall keep clean the place on which the constructions are active during the installation stage until the site is delivered. The Contractor shall be ready to advise the Employer's Engineer of the location and condition of the materials at any time including materials shipped by sea. The Contractor shall provide adequate security staff and all other resources that are needed to safeguard the works and goods (Whether installed or stored) from damage and theft and shall take all reasonable precautions to prevent unauthorised access.

- Utility services (Water, Telecommunication, etc..), the cost of which shall be the sole responsibility of the Contractor.
- Provide adequately equipped site office and facilities subject to the acceptance of and in accordance with the requirements of the Employer, the office space would be provided by the Beneficiary Water Establishments , if available.
- Clear Labelling of all cables (every 5 meters) and devices (inverters, protection devices etc..) where labels must match the as-built drawings. Labels installed outdoors should be UV resistant and weatherproof.
- Supply all operational and maintenance documentation, including list of alarms and fault codes with possible troubleshooting information.
- Conduct adequate training to the Beneficiary's Staff concerning Operation and Maintenance activities as detailed below.
- Perform inspection and testing
- Supply and deliver spare parts as indicated in the Bill of Quantities.
- Supply and install the Project Sign Boards for each site as per the specifications and dimensions to be provided by the Employer.
- Provide visibility requirements regarding labelling of equipment as per the specifications and dimensions to be provided by the Employer.
- All studies, supplies, and works that are necessary to complete the works and deliver fully functional systems, according to the applicable laws, international standards, and best industry practices, shall be provided by the Contractor, even if these are not specifically indicated in these documents.

3. SITE DETAILS

3.1. Location

The locations of the Beneficiary Pumping Stations is as per the below table:

Number	Name Location	Coordinates/ Location	Site Elevations
1	Bechmezzine Well (serving Amyoun)	: 34°19'19.8"N, 35°48'17.4"E	278m Above sea level

3.2. Earthing System

The contractor to test the availability of proper earthing system in the facilities to connect to them. However, earth bars shall be provided at the panels area, to facilitate the equipotential earthing bonding of the newly added solar equipment to the existing earthing system. Connections from these earth bars to the existing earthing system shall be provided. Also, all solar equipment and components shall be connected to the earthing system.

The Contractor shall measure and confirm a resistance of maximum 5 Ohms for all locations used to connect any sections of the PV system. In case of higher earth values measured on site, the Contractor is responsible to make any corrective measures, including but not limited to the addition of earth pits and/or earth bars. Equipotential bonding between all earthing systems connected to the PV system is to be made.

4. GENERAL REQUIREMENTS

The works under these Projects consist of supplying all the systems' components, installing, testing, commissioning, and handing over in good operating conditions in addition to complete O&M training, Supply of Spare Parts, and DNP for the whole systems detailed in this Project.

The Contractor shall provide all necessary components, accessories, human resources, civil works, scaffolding, cranes, HSSE measures (Permanent and temporary installations), miscellaneous services and activities, etc, at the Contractor's own expense to install complete operational units.

4.1. Functional Configuration for the Water pumping station

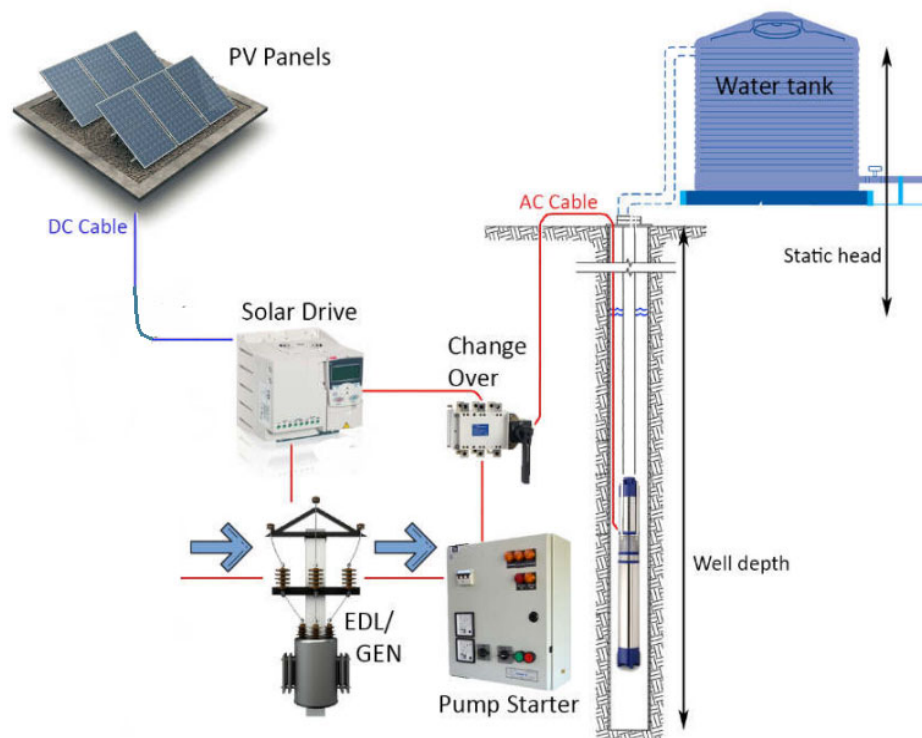
The proposed system is based on connecting the PV panels to a solar variable frequency pump drive that would transfer the produced DC current into AC current to directly supply the well pump. A motorized transfer switch will also change the supply to the existing EDL/ Generator feeding line from

the existing MTS. The main supply would be from the solar system while the EDL and the generator would be the backup system. The PV plant is sized around double the power of the pump to ensure that the output of the plant would be enough even at the early hours and during the seasons and days where the sun intensity is not high. A weather station will be installed to measure the sun radiation and the temperature and give the order to switch to the generator or the EDL supply via the motorized switch.

It should be mentioned that the VFD needs to have harmonics sinusoidal filters to protect the pump motor from the harmonics created by the drive. The VFD, on the other hand, will help smooth the start of the pump and would reduce the water hammer effect when stopping the pump.

The solar drive will be installed inside a new electric room to protect it from vandalism and from weather conditions. The DC cabling of the different strings will be connected to DC combiner panels located underneath the PV panels; then the different DC combiners will connect to a DC totalizer panel that will connect to the solar pump VFD inside the electrical room.

The installation will be fenced to protect it from animals, theft and sabotage.



General system layout

5. TECHNICAL SPECIFICATIONS

This chapter describes the requirements for the main components, the equipment and the design of the Plant.

It should be noted that the equipment offered should be suitable for operation at 380V-400V (3-phase), 50 Hz and there may be voltage sags and voltage surges from the utility grid side.

5.1. PV Modules

- Solar PV panels suitable for the project purposes and local conditions;
- The module rated power should be at least 545Wp at STC;
- The rated output power of any supplied module shall have positive tolerance: up to 5Wp;
- Cell protection: Cells should be protected by anti-reflective coated tempered glass;
- Module shall withstand loads up to 5400 Pascal;
- I-V curve should be supplied;
- Solar PV panel conversion efficiency should be equal to or greater than 20.7 % under STC;
- The supplied module DC voltage should be not less than 1000 VDC;
- The modules shall also be tested through at least one of the following quality and durability programs:
 - Fraunhofer's PV Durability Initiative (PVDI) testing;
 - Atlas 25+ PV durability testing program;
 - PVEL's vendor qualification test program;
 - NREL's Qualification Plus for PV module reliability;
 - VDE Durability Testing Program;
 - TUV Sud Thresher or equivalent; and
 - Proof shall be submitted. Additionally, with clear certificates and highlighting the matching standards in each certificate, I-V curve must be supplied.
- PV modules must be crystalline silicon PV modules that comply with the norm IEC 61215 edition 2 and shall be qualified to and be classified as Class A or B according to IEC 61730. PV modules shall also comply with the requirements of IEC 61701 (Salt Mist Corrosion test) and IEC 62716 (Ammonia Corrosion test);
- PV panels should be procured from tier-1 manufacturers (as per the latest Bloomberg Tier 1 manufacturer listing);

- The PV generator should fit in the available space, and each string should not have higher total Voc than the PV inverter can accept;
- The PV panels must have a minimum manufacturing warranty of 10 years and a performance warranty of a minimum of 25 years. The following minimum power warranties shall be guaranteed:
 - First 10 years at 90% of the nominal rated power output; and
 - Subsequent 15 years at 84% of the nominal rated power output. Or linear power output characteristics can be accepted.
- All modules must be of a robust design. Only certified Mono-crystalline silicon modules, half cut-cells will be accepted from Tier1 Manufacturers;
- Number of cells in a module (acceptable): 60 half cut cells , 72 half cut cells or 78 half cut cells;
- Proof shall be submitted. Additionally, with clear certificates and highlighting the matching standards in each certificate;
- PV modules must be approved to IEC/EN 61215 ,61730-1/2, certified and listed. Certifications have to be issued by an internationally recognized laboratory;
- PV modules shall also comply with the requirements of IEC 61701 (Salt Mist Corrosion test) and IEC 62716 (Ammonia Corrosion test);
- The PV Modules shall be clearly labelled and permanently marked with a data plate containing the following information: manufacturer's name and physical address, type/model number, the watt-peak power rating at STC, open circuit voltage and short circuit current, voltage and current at maximum power point, tolerance and temperature coefficient, country of manufacture, certification, e.g: UL listing, IEC 61215, ISO certification, with fool-proof +ve/-ve connectors;
- Measures against Potential Induced degradation (PID) Including but not limited to:
 - All fixing accessories on module framing;
 - Earthing of the PV modules;
 - Device preventing any risk of electrolytic couple; and
 - Report flash testing of the modules to be provided before installation.
- Modules shall be guaranteed by the manufacturer for 25 years with no more than 10% de-rating for the first 10 years, and 20% de-rating within 25 years; and
- The outside junction boxes with the positive and negative terminals shall incorporate bypass diodes that have the function of preventing any possibility of the electrical circuit inside the module being broken due to the partial shading of a cell.

5.2. Solar Variable Frequency Drives - VFD

- Solar VFD shall be provided as shown on the drawings and schedules and in the bills of quantities;
- Solar VFD shall have built-in pumping applications controller such as:
 - Auto start in Solar mode (No need to turn pumps ON/OFF);
 - Auto-switching between power modes (Hybrid Mode); and
 - Boost–Decrease Flow Rate (Manual, Time Set, Remote).

▪ <u>Input specification:</u>	
PV Input	
Maximum Input DC Voltage	1000VDC
Voc Range	500 ~ 700VDC
MPPT Voltage Range	450 ~ 600VDC
Starting Voltage Range	250 ~ 800VDC
Grid or backup generator input	
Input Voltage	Three phase 380V/400V
▪ <u>Output specification:</u>	
Rated output voltage	3PH 380V
Output frequency	0 ~ 60.00Hz (Default 0 ~ 50.00Hz)

- Enclosure: IP 65 minimum;
- MODBUS or CAN (with communication bridge if required), allowing reading and writing on the inverter;
- Compliance to IEC/EN 61000-6-1/2/3/4, IEC/EN 62109-1, IEC/EN 62109-2;
- The 'European Efficiency' of the inverter shall be a minimum of 96%;
- Include Sine Wave filter as per UL 61800-5-1, EN 61800-5-1;
- Permissible harmonics order as per as per IEC 61000-3;
- Ambient Temp Range: -10C to 50C;

- Built-In data logging and a simple management interface;
- Ability to be remotely monitored and managed via a web application service;
- Maximum Power Point Tracking (MPPT);
- Highly efficient maximum power point tracking with pump system specific algorithms;
- Active power management for temperature;
- Automatic and active power management to ensure the system continues to run in even the most extreme temperature conditions;
- Digital inputs for connection of well probe, tank full, pressure switches and remote switches;
- Analogue inputs for sensors. Applications included for pressure and level monitoring and pump control;
- Sun-Sensor function allows the controller to block pump operation once solar irradiation levels drop below a minimum threshold for optimizing operation;
- Variable frequency output to allow maximum water to be pumped based on available power;
- Soft start and infinite control of motor speeds for long life and low generator loads;
- Signal output for controlling externally connected devices;
- Low voltage DC input to allow bench / field configuration when 3 phase power is not available;
- Constant pressure and flow built in applications to limit or to provide minimum pressure and flow;
- Control of the pump system using pressure sensors for remote control applications and pressure dependent processes;
- Built in system timers for providing time of day or interval timing control;
- Power choice control giving the ability to prioritize water delivery or power type (cost) in hybrid applications: for example, the priority is given to the water pumping function using the solar energy when the EDL supply is available or vice-versa i.e. the flexibility to set-up any control and operation scenario;
- Automatic data logging of all running pump data. Recording frequency is configurable with capacity for up to 10 years;
- Simple LED display to indicate system status;
- Simple configuration with remote application;
- Local and remote monitoring and management with a well-developed web interface;
- An external Sinusoidal filter to be included as deemed necessary by the controller manufacturer given implementation constraints;

- Configurable set points for minimal frequency power drive to ensure optimized commissioning settings for pump switch off at low power values;
- Integrated filter ensuring a sinusoidal phase to phase voltage transmission to the motor;
- 5 years warranty;
- To be protected from direct sunlight by not facing the sun during the mid-day and provided with sun shade or awning; and
- A pad or platform shall be provided to ensure operators/electricians will not be standing in water or mud while working with the equipment;

5.3. DC and AC cabling and cable routing

- All cables and connectors used for the installation of the solar array must be of solar grade robust and durable in harsh environmental conditions including High temperatures, UV radiation, rain, humidity and dirt as per IEC standards;
- DC Cables outer sheath shall be electron beam cross-linked XLPE type, or equivalent. Cable Jackets should also be electron beam cross-linked XLPE, flame retardant, UV resistant. 4mm² or 6mm² cables can be used;
- Cables terminations shall be made with suitable cable lugs & sockets etc., crimped properly (with torque wrenches) to manufacturer recommended torques and passed through brass compression or screw-type connectors, through cable glands at the entry & exit point of enclosures, or equivalent. Terminations of Aluminium cables should be done with the highest standards, using specialized cable lugs. The lug barrels must be factory prefilled with a joint compound;
- All cable/wires shall be provided with UV resistant printed ferrules for both DC and AC sides. The marking on tags shall be done with good quality letter and number ferrules of proper sizes so that the cables can be identified easily. All cables must be labelled at the source connection, on the way, and at the end of connection;
- All cable trays shall be of heavy duty perforated type with return flange, and shall be manufactured from hot-dip galvanized steel, with a standard heavy duty galvanizing coating of 350 g/m² and Z2 bending grade;
- All accessories and fittings such as bends, tees, elbows, cross units and angles shall be of the same specification as that of the cable tray finish and shall be standard products from the same manufacturer as the cable tray. Site fabrication shall not be permitted;
- Cable trays and accessories shall be of a thickness of not less than 1.5 mm for up to 300 mm width trays, and not less than 2.0 mm above 300 mm width;

- AC Cable trays shall have a spare area of 50% of the whole section, a minimum distance equivalent to one diameter of the AC cables is to be left between cables on the cable trays;
- DC Cables can be bundled in exposed corrugated metallic conduits, fixed to the solar system metallic structure. The corrugated conduits shall be made of Stainless steel (316L) with stainless steel (316L) over braid and shall have the following properties:
 - IP rating: IP68;
 - Temperature range -100°C to +400°C;
 - High Mechanical Strength;
 - High Abrasion resistance;
 - Pull off strength: 150kg (20mm);
 - High compression strength 1000 kg/100mm;
 - Inherent low fire hazard;
 - Excellent Corrosion resistance;
 - Oil resistant;
 - UV resistant;
 - Provides EMC screening; and
 - Offers Antistatic properties.
- All PVC conduits and fittings shall be UV resistant uPVC heavy gauge, rigid, direct buried or encased buried type as applicable, complying with BS 6099-2.2 / IEC 614-2-2 heavy gauge in all respects, and may be used where ambient temperatures do not exceed 75 °C;
- All PVC conduits and accessories shall be obtained from the same manufacturer;
- No conduit shall be less than 20 mm diameter;
- Fittings and accessories for PVC conduits shall include, but not be limited to, the adapters, junction/pull boxes, bushings, couplings, elbows, nipples, plugs, seals, etc.;
- Conduit boxes shall be of the circular pattern with appropriate spout entries and 50.8 mm accessory fixing centres;
- All connections and terminations of the PVC conduits and fittings shall be by means of the manufacturer's standard adaptor;
- All boxes shall have brass thread;
- Cables with different voltage levels shall be separated by use of different cable ladders or trays. Particular attention should be given to separating Power lines from control cables;
- Cable trays in accessible areas shall be protected by use of a cover;

- Cables which are installed on cable trays that are running on the floors with no means of anchoring to the floor should be supplied with counterweights;
- For underground power cables in trenches: Excavated in a depth of min. 90 cm. The bottom of the trench shall be smooth, compacted and free of stones, roots and pipes. The bottom of the trenches shall be covered with a 15 cm layer of riddled, stone-less sand. After laying of the electric conduits, they shall be covered with a further layer of the same sand, depth 15 cm. A second layer of 3 conduits for control cables is then laid in place, covered with a third layer of 20cm sand. Remaining volume can be backfilled from excavated soil and should be compacted to a minimum of 90% relative compaction. A warning tape and a bare copper earth bonding cable should be installed as detailed in the trenches drawings. Surface repair should be done to restore to the same or better conditions; and
- For underground control cables in trenches: Excavated in a depth of min. 70 cm. The bottom of the trench shall be smooth, compacted, and free of stones, roots and pipes. The bottom of the trenches shall be covered with a 15-cm layer of riddled, stone-less sand. After laying of the control conduits, they shall be covered with a further layer of the same sand, depth 15 cm. Remaining volume can be backfilled from excavated soil and should be compacted to a minimum of 90% relative compaction. A warning tape and a bare copper earth bonding cable should be installed as detailed in the trenches drawings. Surface repair should be done to restore to the same or better conditions.

5.4. Control and signal Cables

- Multi core insulated cables suitable for outdoor use and laying under-ground, with copper conductor and copper shielding;
- The cables shall be provided with a min. of 20% spare conductors, except for the inter-inverters control cables; and
- Separate cable trays or conduits shall be used for LV and control / signal cables.

5.5. Electrical Panels

- Class II boxes suitable for outdoor use (minimum IP65 protection if implemented outdoor, in compliance with the applicable standards which should be sunlight/ UV resistant as well as fire retardant);
- Components inside electrical panels as per SLD diagram;
- Included tracking labels and signal "Warning: energized cables " and "Do not operate in charge" both in Arabic and English language;

- All electrical boxes must be labelled with permanent marking denoting the associated inverter and MDB numbers as per the as-built drawings;
- The boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables preserving the IP of the box;
- The electrical boxes must be grounded properly to ensure all safety related measures for safe operation;
- All the electrical boxes to be manufactured with sufficient space for easy handling and must have temperature suitability for local conditions and maximum current rating;
- The AC panels busbars shall be:
 - Site rated for normal current as shown on the Drawings and braced for a symmetrical RMS short-circuit duty as specified. Busbars are to be copper, of sufficient size to limit temperature rise to allowable insulation or equipment temperature ratings, and to maximum 90 deg C. Connections and bus work are to be bolted with copper alloy hardware and are to be accessible for inspection and maintenance unless otherwise recommended by the manufacturer and approved by Engineer. Contact surfaces are to be Electro-silver plated;
 - Connections from busbar to panel are to be rated to carry full continuous current rating of switchgear frame and are to be insulated. Full size neutral is to be continuous through all sections. Neutral bus is to be insulated and separate from the earth bus and connected to it with removable links, at every bus section. Links are to be of the same cross-section of the earth bus; and
 - Here Below, is a schedule showing the constructional details of copper busbar (weight, area, size & number of bars according to the current carrying capacity at 35°C ambient temperature.

5.6. Pumping Station Solar Controller

- The pumping station PV plant controller unit shall have a minimum track record of 4 years in operation in similar conditions;
- The controller will continuously monitor the diesel generator (DG) output and EDL incoming and the frequency drive inverter input and output via dedicated meters (independent from the GCU measurements), as per SLD;
- The Contractor shall supply and install power meters, dry contacts, current transformers, or necessary measurement accessories on the genset and grid power lines to read the genset's and grid's operational parameters;
- The controller shall always be maintained online even during power transfers between the different power sources and for this reason an on-grid solar system will be provided for this purpose;

- Communication: RS485, Ethernet (compatible with the different meters);
- The solar Controller shall be able to perform the following functions:
 - Emergency shutdown for the PV system; and
 - Turn on the generator when the solar energy is not sufficient to turn on the pump and switch to the solar pumping when the solar inverter and weather station input indicated enough solar power is available.
- Trip the PV system at any time there is loss or interrupt of communication with the VFD frequency drive;
- All additional necessary accessories needed for proper functioning of the controller are to be installed and commissioned;
- All operating parameters from the controller should be fully logged in the dedicated logger;
- Shall allow MODBUS communication for read of its registers; and
- Warranty: Minimum 2 years.

5.7. Earthing System

- All PV structures and PV modules should be grounded properly. Suitable accessories for bonding between copper and metallic structures to be used, to avoid potential difference induced corrosion;
- Piercing PV clamps should be used to bond PV panel frames on the same row;
- Continuity test should be done after each array connection to insure proper panel bonding;
- All metal casing/shielding of the system and its components should be thoroughly grounded;
- Earth resistance should be tested in presence of the Employer representative by a calibrated earth tester, the earth resistance should not be more than 5 Ohm;
- Earthing installation in accordance with the IEE Wiring regulations BS 7671; and
- The PV system earthing will be connected to the existing earthing after performing all the required tests.

5.8. Fire Fighting System

Portable fire extinguishers to be provided near the PV installation site and the main electrical rooms as shown on the drawings and provided in the bill of quantities. The portable fire extinguishers shall have the following characteristics:

- Shall be of the dry chemical type A,B,C;
- Shall be UL listed;

- Shall be 4.5 KG;
- Aluminium valve and handle;
- Hose discharge;
- Shall have wall bracket and shall be installed on the nearest wall or on the parking sheds structure nearest to the inverter;
- Shall be suitable for outdoor installation; and
- Minimum warranty of 2 years

5.9. Documentation, Training, and O&M Plan

a- Documentation

The Contractor is required to submit the following documentation:

- Detailed engineering report, to be approved by the Employer before the start of work. Including civil construction drawings, physical layout drawings, functional drawings, SLDs, structural calculation notes, shading loss calculation, cable and protection sizing calculations, all technical datasheets and other manufacturer's technical documentation;
- BOQ per site;
- Factory acceptance test reports;
- As-built drawings and technical documentation (Including catalogues, brand names, model numbers of all equipment and materials installed in the Project, along with contact details of the suppliers/ Manufacturers) in English; and
- Operation and Maintenance manuals in English.

b- Training

The Contractor is required to conduct the following training to the Beneficiary's staff:

- Training on Plant Operation and Maintenance of the complete installed system components. Under this training the Contractor shall provide technical and safety training for the pertinent facility staff (Engineers, technicians, etc..) on all operational and maintenance aspects for the Plant including but not limited to:
 - Start-up and shut-down of the solar plant;
 - Remote monitoring system and logging system;
 - Inverter functionality, resets and interface;
 - Solar panels cleaning and panel replacement;
 - All protection devices operation and functionality; and

- Any other necessary discipline.

The number of the beneficiary trainees shall not be less than six (6) staff.

The number of training sessions and the training duration shall be agreed upon with the Employer and the Beneficiary, however, the training days shall not be less than two days per site. The frequency and the dates on which the training sessions would be performed shall be agreed upon between the Contractor, the Employer and the Beneficiary.

c- O&M Plan

The Contractor is requested to deliver a short operation, control and maintenance plan for the plant including the following:

- **Preventive Maintenance (PM):** The preventive maintenance plan prepared for the Plant shall include all necessary measures to be followed by the Contractor in accordance with the manufacturers' manuals and shall include, but not be limited to, the following:
 - Provision of sufficient and calibrated measuring devices to carry out PM;
 - Recording all maintenance tasks in a maintenance log;
 - Periodic checks of the plant's components in accordance to the maintenance plan;
 - Maintenance of all civil, mechanical, and electrical components at least in accordance to the manufacturer operation and maintenance manuals and instructions; and
 - Maintenance of the control and monitoring system.
- **Corrective Maintenance (CM):** The corrective maintenance plan of the plant shall always include and in all cases attending to and repairing breakdowns and failures of the components of the plant caused by wear and tear and/or breakage under normal operating conditions to ensure that the Plant operates normally throughout the duration of the O&M contract. The CM plan shall include, but not be limited to, the following:
 - Supplying component and spare parts needed to replace those requiring repair in the event of a breakdown or anomaly;
 - Repairing or replacing component or parts of the plant where necessary;
 - Keeping and managing a minimum stock of spare parts;
 - Response times for each type of event, from minor to critical, should be within 1 day; and
 - Claim management.
- **Reporting**
 - **Monthly reports** shall be prepared including:
 - HSSE information, including significant events;

- Details of significant operational events for each major item of equipment;
- Occurrences and consequences for plant operation;
- Maintenance activities performed submitted with complete detail of defects occurred and rectification measures executed (preferable to be logged for each individual equipment);
- Calculation of Net Electrical Energy for the reporting period;
- Aggregate Net Electrical Energy delivered at the connection point to date;
- Monthly and aggregate electrical energy generation from each of the Plant's inverters;
- Monthly weather data collected from each of the weather sensors; and
- The monthly and year to date Performance Ratio- PR of Plant.

Status reports after any incident on Site and/ or Plant tripping shall be also prepared.

5.10. Structural Design Criteria

The Contractor shall provide detailed design including detailed drawings and calculations notes and simulation for the parking canopies. The configuration shall be similar to the one shown on the layout drawings and sections , but it shall be the responsibility of the Contractor to provide his own shop drawings within the drawings guidelines and in conformity with the following codes and basis of design :

A. Codes of practice and standards

Structural steel design and verification shall be based on the recommendations of the following codes and standards:

Built up and hot rolled sections:

- AISC-360. "American Institute of Steel Construction" Manual of Steel Construction - LRFD method, 2016 Edition.

Cold formed components:

- AISI. "American Iron and Steel Institute" Cold Formed Steel Design Manual, 1996 Edition.

Welding in accordance with:

- AWS D1.1/D1.1M:2004 "American Welding Society" Structural Welding Code - Steel Manual, 2004 Edition.

Reinforced concrete elements in accordance with:

- ACI 318. "American Concrete Institute" Building Code Requirements for Structural Concrete, 2019 Edition

B. Basic Loads and Load Combinations:

The loads shall be applied on the structure in accordance with:

- ASCE – 07 “American Society of Civil Engineers” Minimum Design Loads for Buildings and Other Structures, 2016 Edition.
- IBC 2018, “International Building Code”, 2018 Edition
- Lebanese Norm NL 135, “Seismic Loading”, 2012 Edition
- Lebanese Norm NL 137, “Wind Loads on Structures”, 2020 Edition

C. Material

Steel Structure

All hot rolled members and plates shall conform to ASTM A36, with a minimum yield stress of 235 MPa and ultimate stress of 360MPa.

All cold formed members shall conform to ASTM A653, with a minimum yield stress of 235 MPa and ultimate stress of 360MPa.

All reinforced concrete elements shall have a minimum cylindrical compressive strength of 30Mpa. Steel reinforcement shall have a minimum yield stress of 420 MPa. The steel structure shall be painted to the satisfaction of the Client as per the following specifications:

1.Primer:

A zinc rich primer coat, adequate to the site conditions , shall be applied by spraying .. The thickness of the film is 60 micron (1 layer).

2. Intermediate Paint

Apply High Build Epoxy Intermediate paint with minimum dry film of 80 micron thickness for the whole area (2 layers)

3. Final Coat

Apply a finish coat P.U. with minimum dry film thickness of 50 micron.

4. Notes

The products and the applications should be conforming to a warranty of 10 years before the first maintenance.

CEMENT

1. Cement shall comply with ASTM C150, Type I (ordinary Portland cement), Type II (moderate sulphate resisting cement), and/or Type V (sulphate resisting cement), all as indicated in the "Concrete Mix" stated below.

2. White or colored cement shall comply with ASTM C150.
3. The cement shall be obtained directly from an approved manufacturer or an approved supplier and shall be delivered either in bulk by purpose built vehicles or in sealed bags. All cement shall be free flowing and free of lumps.
4. The total alkali content of the cement expressed as the sodium oxide equivalent shall not exceed 0.6% by weight.
5. The tricalcium aluminates (C3A) content of ASTM C150 type I cement shall range from 7.5 to 11%, and for ASTM C150 type II and type V sulphate resisting cement shall not exceed 5%.
6. The sulphuric anhydride (SO₃) content shall not exceed 2.3%.
7. The heat of hydration shall not exceed values listed in ASTM C150.
8. The initial setting time and the final setting time shall be as per ASTM C150.
9. Certificates of cement tests by the manufacturer will be called for by the Engineer. If such certificate is not made available, or if the Engineer considers that the manufacturers tests are inadequate, samples for testing shall be taken from different consignments as the Engineer may direct. Such samples shall weigh not less than 7 kg and shall be selected and tested.

REINFORCEMENT

1. Reinforcing steel deformed bars shall conform to the requirements of the following:
 - a. ASTM A706/A706M, 420 MPa minimum yield strength; deformed low-alloy steel bars, unfinished. OR
 - b. ASTM A615/A615M, Grade 60, 420 MPa minimum yield grade; deformed steel bars, unfinished.
 - c. Deformed reinforcing bars shall conform to one of the ASTM specifications listed above except that for bars with specified yield strength exceeding 420 MPa, the yield strength shall be taken as the stress corresponding to a strain of 0.35 percent.
 - d. The values of reinforcement specified yield strength used in design calculations shall not exceed 550 MPa.
2. Reinforcing Steel Plain Bar Stirrups and Rod Mats: ASTM A704/A704M, ASTM A615/A615M, 280 MPa; steel bars or rods, unfinished.
3. Welded Steel Wire Fabric: To ASTM A497 Deformed Type.
4. The weight of steel bar reinforcement for each bar diameter shall be in accordance with BS 4449: 1997: "Specification for Carbon Steel Bars for the Reinforcement".

6. STANDARDS OF PERFORMANCE

6.1. General

The Contractor shall perform the required services and carry out the Contractor's obligations under this Contract with all due diligence, efficiency and economy, in accordance with generally accepted techniques and practices used in performing such types of activities and with professional engineering and contracting standards recognised.

The Contractor shall observe sound management, and technical engineering practices, and employ appropriate advanced technologies and safe and effective equipment, machinery, materials and methods.

The Contractor shall operate and maintain the equipment and machinery involved in the implementation activities in accordance with the relevant laws, standards, regulations and legislation, as well as the requirements under the Contract, and the manuals and guidelines as provided by the manufacturers and suppliers of the equipment and machinery.

No construction works shall start at the selected sites until the work plan, submittals, shop drawings, deliverables manuals and technical specifications are prepared by the Contractor and approved by the Employer.

The latest editions of the Standards, Codes and Recommendations issued by the following organizations must apply for the engineering, construction, testing and commissioning of the Facility. International Standards (Highest precedence):

- ISO International Standardization Organisation; and
- IEC International Electrotechnical Commission.

6.2. Site Operating Procedures

The Contractor should assign a surveyor to carry out site topographic surveys as might be needed for the proper execution of works and to ensure the site work is in line with the required specifications. The Contractor should also assign a resident site engineer to follow-up on the works and to coordinate with the Employer Project Engineer. The site engineer shall have a good knowledge and practical experience in constructing irrigation canals. The Contractor site engineer shall report on a weekly basis to the Employer Project Engineer on the progress of the work. In case of any changes, the Contractor site engineer shall inform the Employer Project Engineer before proceeding with any modifications. The Contractor shall maintain a good level of coordination with the project staff, beneficiary team, and the local community especially the Municipality in order to ensure smooth implementation of the fieldwork.

6.3. Movement of Heavy Machineries & Equipment between Different Parts of the Site

The Contractor shall move the heavy machineries and equipment from one location to another in a safe and proper manner such as not to have any adverse impact on the neighbouring properties or causing any damage to the natural environment in the area.

6.4. Contractors obligations with the municipality and official authorities

The Contractor shall be responsible to obtain the pertinent licensing and permissions concerned with the construction of the Solar PV Systems at the Beneficiary sites in accordance with the pertinent regulations, especially those issued by the Ministry of Energy and Water and the Ministry of Interior and Municipalities. In this regard, the Contractor shall be responsible to obtain the pertinent documents from the Beneficiary sites, however, the Contractor shall be responsible to fill in the necessary forms and to submit the same and to follow up with the pertinent authorities. In performing this task, the Contractor shall keep the Employer and the Beneficiaries informed about the process in due time.

The Contractor should always coordinate and inform the beneficiary team and the municipalities and any concerned authorities for any temporary blockage of roads or any road found necessary to execute the works – if the latter applies. The Contractor shall keep the Employer's Project team informed about such coordination, however, the sole responsibility shall be that of the Contractor.

The Contractor is responsible to set up meetings and shall follow up any issue related to this project with the local and national authorities. The Contractor shall not accept any request for additional works from the municipality and official authorities. Any amount resulted from the additional works not included in the Contract shall be borne by the Contractor.

6.5. Contractor's liability

Approval by the Engineer on any Contractor's submittal shall not release the Contractor of any of its responsibilities and liabilities under this contract.

The Contractor is also liable to highlight in writing, within 2 weeks from signing the Contract, any mistakes, errors or omissions in design and details that are likely to affect the Contractor's performance of its obligations under the Contract. Should the Contractor fail to abide by this set time frame, it shall risk losing all rights and entitlements arising from the same.

This sub-clause shall not be construed to apply to differences in quantities mentioned in the BOQ, which shall be dealt with in accordance with section related quantities mentioned in the BOQ.

6.6. Reporting

The Contractor shall submit the following reports:

- A. Weekly report using a form agreed on with the Employer's team, showing the works done with clear photos and a provisional schedule for the week after.

- B. Look Ahead Schedule to be submitted on a weekly basis depicting the tasks performed during the last week, the work planned to be executed during the upcoming week.
- C. Monthly progress report. This progress report shall include:
 - i. Photographic records;
 - ii. The completed tasks of the previous week complete with pictures;
 - iii. An excel sheet detailing the progress of the overall implementation;
 - iv. A schedule of planned work for the upcoming week;
 - v. The log sheets for the projects;
 - vi. The log sheet for the possible variation order & extension of time;
 - vii. The updated time schedule, showing the progress of works, the occurred delay if any;
 - viii. Brief description of the project;
 - ix. HSSE information, including significant events; and
 - x. Other information as might be requested by the Employer.

In addition to the above, the Contractor shall install Time-Lapse Cameras to record the progress of the works in all of the sections of each site of the Project and to produce videos and photos as per the requirements of the Employer.

6.7. Submittal and Review Periods

Within seven (7) calendar days of signing the Contract, the Contractor shall submit for the Engineer's approval a schedule of document submittals, detailing all submittals to be made along with their expected submission dates. This schedule should cover all anticipated document submittals, such as but not limited to all types of reports, materials submittals, shop drawings, method statement, As-built drawings, etc. The schedule of submittals must consider that all submittals should be furnished to the Engineer within eight (8) weeks from signing the Contract (As-built drawings within one week prior to the taking over of the Plant/ weekly and monthly reports shall be submitted as per their periods), and should specify the material delivery period related to each of the listed material submittals.

Submittals shall be developed through the standard forms of the Engineer, which will be communicated to the Contractor during the kick-off meeting. It remains the Contractor's responsibility to formally request these forms in case they are not provided during the said meeting.

Any necessary re-submittal shall be issued within 5 calendar days from the request date. Delays resulting from failure to obtain approval from the first submittal shall be the sole responsibility of the Contractor.

Timely submission of the submittal schedule shall form a prerequisite for releasing any due payment

under the Contract. Delays in finalizing submittals in accordance with the approved schedule of document submittals could result in suspending any due payment to the Contractor until all required submittals have been provided to the satisfaction of the Engineer.

The Engineer shall reply to the Contractor within ten (10) calendar days of receipt any submittal, provided that where batch submittals are issued by the Contractor, additional days for revision shall be entitled as reasonably required.

Any received / approval of Contractor's submittals (shop drawings, materials submittals, procedures, method statement, tests, inspections, etc...) shall in no way release the Contractor of his responsibilities under the contract.

6.8. Warranty

Under this contract, the Contractor should provide the warranties mentioned in the specification for each item. Moreover, for each warranty, the Contractor should provide a local representative office in the country and after sales service for equipment/parts. Below is a summary of the warranties required for the main equipment:

Item	Warranty- yrs.
PV Panel	25
Inverter / VFD/ Filters	5
Steel Structure	10
UPS	2
Lighting Fixtures	3

6.9. Applicable Codes and Standards

- For PV system: Comply with the following Standards:
 - IEC 61724-1 PV standards that is responsible for defining the terminology and classifying the equipment and methods necessary to monitor and analyse the performance of solar energy plant systems - ranging from irradiance input to AC power output;
 - IEC 62548:2016 that sets out the design requirements for photovoltaic (PV) arrays including DC array wiring, electrical protection devices, switching and earthing provisions. The scope includes all parts of the PV array up to but not including energy storage devices, power conversion equipment or loads; and

- IEC 61215 standards for durability and performance for standard monocrystalline and polycrystalline PV modules.
- For the earthing system:
 - Carry out work in accordance with the following:
 - IEC 60364-1 and 60364-4-41: Electrical Installations in Buildings.
 - BS 7430 : Code of Practice for Earthing.
- For DC cables:
 - Cables are to comply with EN 50618 & IEC 62930
- For Solar Frequency Drive:
 - To comply with EN 50178, EN 60204-1 & EN/IEC 61800-5-2 & IEC 61800-5-1, CE, UL, CUL.
- For Sinusoidal filter:
 - To comply with UL 61800-5-1, EN 61800-5-1.
- For ON-Grid inverter:
 - To comply with IEC/EN 61000-6-1/2/3/4, IEC/EN 62109-1, IEC/EN 62109-2.
- For AC cables:
 - Cables are to comply with IEC 60502.
 - Carry out work in accordance with the following:
 - IEC 60332: Tests on electric cables under fire conditions.
 - NFPA 70
- For AC panels:
 - Carry out work in accordance with the following:
 - IEC 60439-1 "Low Voltage Switchgear and ControlGear Assemblies".
 - IEC 60974-1 Low voltage switchgear part1: general rules.
 - IEC 60947-2 Low voltage switchgear part2: circuit breaker
 - IEC 60898 "Miniature circuit breakers"
- For equipment and materials, Comply with the following Standards:
 - Unless otherwise specified, equipment and materials are to be manufactured and installed in compliance with the relevant recommendations of the following or other equal and approved standards:
 - NFPA: National Fire Protection Association;
 - IEC: The International Electrotechnical Commission;

- IEEE: Institute of Electrical and Electronics Engineers (For Earthing);
- ISO: The International Standardization Organization;
- CCITT: The International Telephone and Telegraph Consultative Committee;
- CCIR: The International Radio Consultative Committee;
- CISPR: The International Special Committee on Radio Interference;
- CIBSE: Chartered Institution of Building Services Engineers;
- NETA: International Electrical Testing Association (tests for site acceptance);
- IEE: Institution of Electrical Engineers;
- BS: British Standards; and
- Underwriters Laboratories (UL)