

الجمهورية اللبنانية

وزارة الأشغال العامة والنقل

مصلحة استثمار مرفأ طرابلس

PROJECT GENERAL DESCRIPTION

TECHNICAL SPECIFICATION FOR SOLAR PHOTOVOLTAIC SYSTEM AT THE COURT OF AUDIT - BEIRUT

الشروط الفنية لمشروع توريد وتركيب نظام طاقة شمسية لصالح

ديوان المحاسبة - بيروت

Proposed to

Port of Tripoli

Website: www.oept.gov.lb

Tel: +961.6.220180

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I. Introduction

The port of Tripoli is looking to provide solar energy support to the Court of Audit in Beirut to help them overcome their hardships and allow them to get back to work in normal conditions and to reduce fuel consumption.

Currently the main electrical source in the Court of Accounts is 2 private generators, 150 kVA and 100 kVA.

Project location on google maps:

<https://www.google.com/maps/place/Diwan+el+Mouhassabeh/@33.89542,35.4962686,102m/data=!3m1!1e3!4m12!1m6!3m5!1s0x151f16df1c760f67:0xf4f4bd46b6d06fef!2sEl+Murr+Tower!8m2!3d33.8953066!4d35.4964437!3m4!1s0x151f17a4aa2c1e87:0x2f6eb2938cf1b9a3!8m2!3d33.8956762!4d35.4965895>

II. General notes and methodology

Court of Accounts main working hours are from 8:00AM till 3:00PM in a building formed by 8 floors in Beirut near El Murr tower.

The main critical offices to feed are the fourth, sixth and seventh floors. Each floor contains two main electrical panel board that divide it into 2 parts.

All connected together in the generator room.

Solar photovoltaic system will be divided into two parts.

System 1: The main concern of this part is a continuous electricity supply and providing the minimum needed power for the offices to be able to operate during the working hours. Unfortunately, the building is very close to El Murr Tower, and the tower is located to the South of the building. This issue is the reason to not benefit from total available solar energy all over the day.

The suitable space to install solar panels is the flat roof of the building. Solar modules should be installed at low level as per Solider company's rules. Installation of modules and structures above the roof concrete limits is not allowed to maintain an esthetic view of the region.

Thus, the available space on roof at low level and the presence of the tower will limit the size of solar system and will not be enough to feed the offices without intervention of fuel generator.

In addition, there are many vent pipes for sanitary on roof and at high level. These pipes should be cut to the minimum acceptable level (after taking approval) to reduce shadings and spaces between modules. Also, the compressors for split units should be relocated (without any extra charges in cost) in a way to benefit from the maximum available space.



Figure 1: Court of Accounts roof & El Murr Tower



Figure 2: Court of Accounts top of roof

The maximum load for system in summer can reach 120A/phase.

In other seasons the load is around 70A/ phase.

Solar modules for system 1 can be installed on the roof and top of roof and oriented to the South as below:

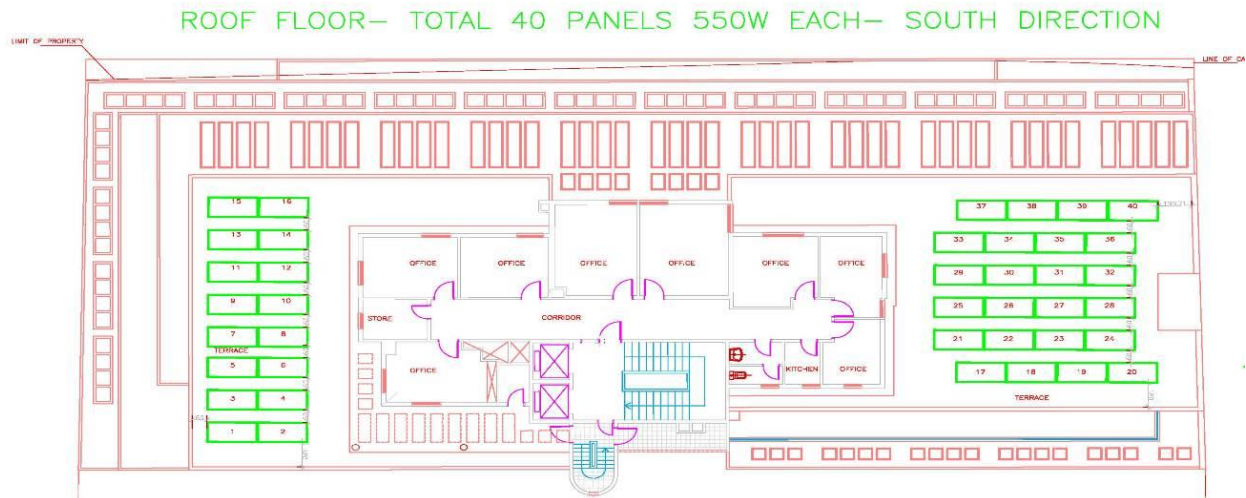


Figure 3: Roof modules distribution on terraces

The roof of the building contains offices in the middle, this is why modules will be installed on 2 available terraces as per figure 3.

The top of roof consists of a concrete tank, a lift room and the ceiling of the offices. Modules can be installed on the flat ceiling, to the right, left and behind concrete tank as below:

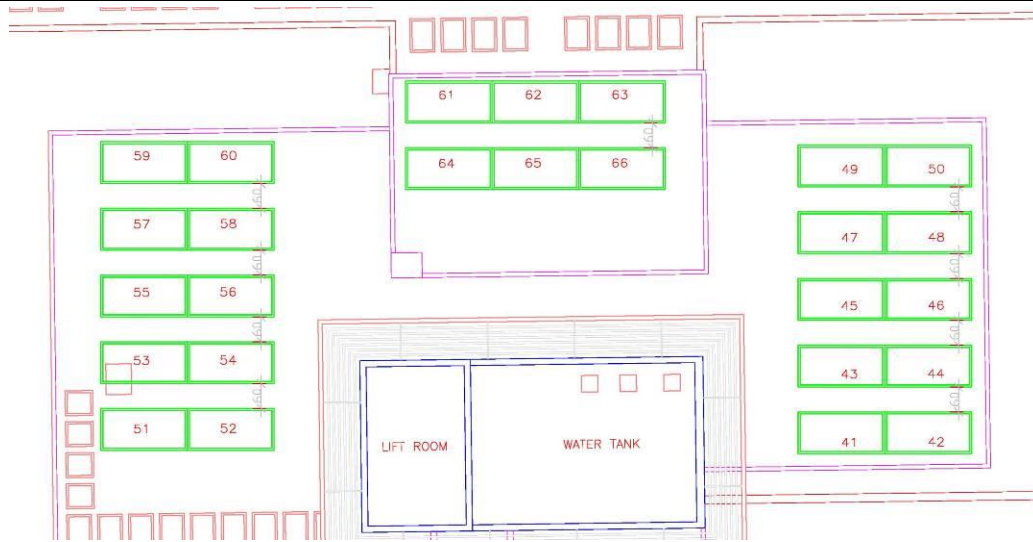


Figure 4: Modules distribution on top of roof

This system requires an ON grid solar system to reduce the fuel consumption according to the solar energy produced from the available space of modules. The management in using the load is a mandatory. Knowing that solar energy is not constant and will vary according to the season and weather conditions, this difference will affect the number of offices that can be supplied with power throughout the year. Thus, the minimum available energy should be serving the office computers as first priority, then lighting fixtures.



Existing lightings in corridors and offices are not LED and not in good conditions. Replacing lights fixtures in offices and corridors for all floors will reduce the consumption and thus to benefit more from solar energy.

Figure 5: Corridor lights

System 2: The main concern of this part is a continuous electricity supply for the server's room. This system requires a battery bank for a continuous supply of 20A. Solar system and generators are responsible to charge the battery bank. To reduce the consumption of server room, the existing air conditioner should be replaced by a new inverter type one.

III. System main components

system1: The proposed solution for system 1 is to be formed of solar PV panels installed on flat roof and top of roof, ON grid inverter (s) to be installed in one of the offices on roof supplying the building. Existing generators to be completely tested, maintained and to be synchronized.

Some modifications should be applied in the existing electrical main panel board to link the EDL and generators to the PV system.

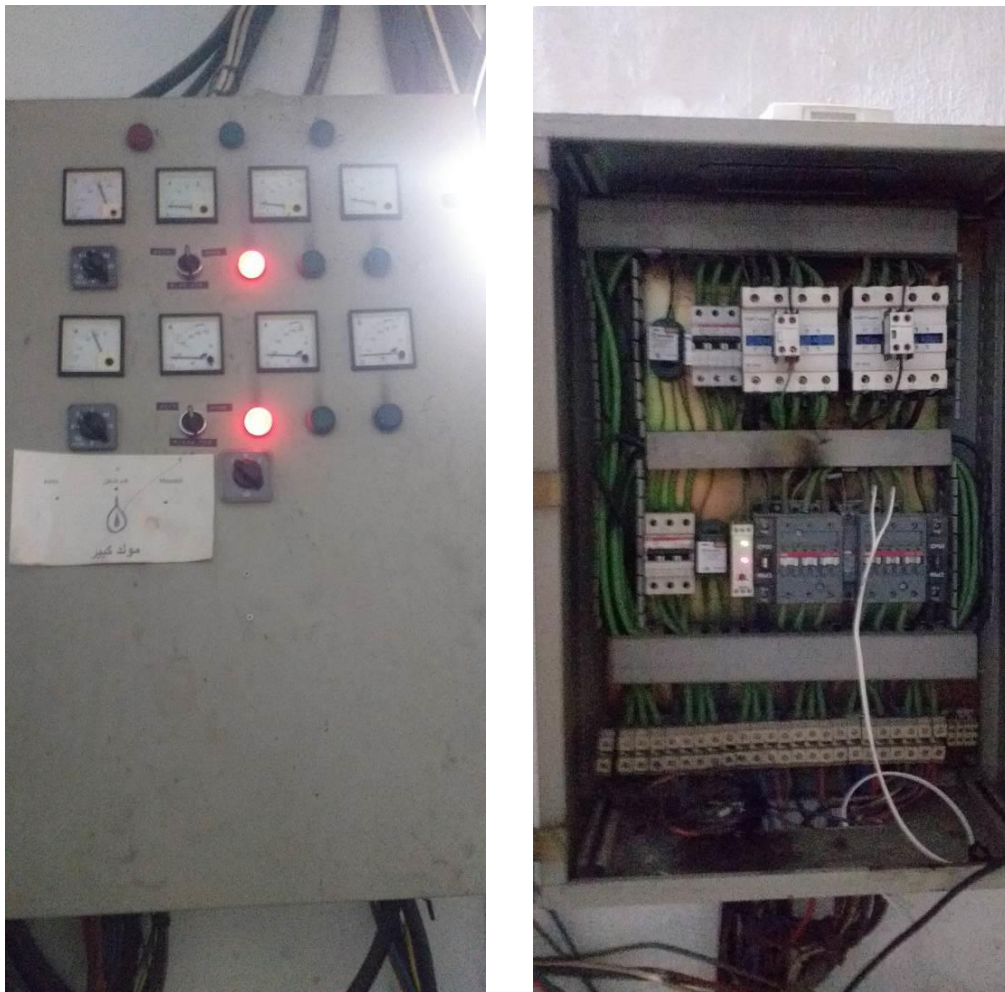


Figure 6: Main existing panel board in ground floor

Structure used to fix solar modules on pitched and flat roof should be made from anti-corrosion materials preferably anodized aluminum based.

The size of each Solar PV panel should be 550W. For the selected area, the number of panels can be 66 modules. Modules are distributed as 40 pieces on roof and 26 pieces on top of roof. Thus, we obtain a total of 36.3 kWp PV system.

System 2: This system dedicated to feed the server room consist of hybrid inverter 5kW, 48V and lithium battery bank of 60kWh to be installed in server's room.

IV. Design parameters & General notes

- Electricity supplied from EDL is considered available for 4 hours only out of 24.
- Private generators sizes are 100kVA and 150kVA are available but not in good conditions. Maintaining these generators and connected it in synchro is a must.
- Working time: from 8AM to 3PM.
- Continuity of supply to server's room via battery bank is critical.
- PV panels installation is available on flat roof and flat top of roof.
- The contractor should take into consideration in the final design the ability of the system to be operating with the existing diesel generators, with all needed control and protection for this purpose.
- Replacing the existing lighting fixtures with LED fixtures is a must to reduce Court building's consumption and increase the benefits of the solar PV system in terms of fuel consumption reduction. There are around 20 offices in each floor, and most of the lighting fixtures are not LED. Therefore, there is around 640 lighting fixtures in the offices, and 400 in the corridors that need to be replaced.
- The contractor will be in charge of the preparation of the solar PV application, to be submitted as per the Ministry of Energy and Water's procedure for solar PV installations, and will be also responsible for the technical follow-up for approval.
- The bidder shall provide a civil design simulation based on wind loads as per Lebanese Standard NL 137:2020, signed by a civil engineer member of the Order of Engineers and Architects of Beirut or Tripoli. The simulation shall demonstrate that the solar PV system is supported by the roof and the fixation can withstand the wind loads as per NL 137:2020.

- The bidder shall provide a copy of the membership card of the civil engineer in the Order of Engineers and Architects of Beirut or Tripoli.
- Control system is required for solar system to ensure the good and safe operation of the installed systems with existing power sources, including but not limited to power export limitation with generator's subscription(s), diesel generators, or EDL.
- System 2 shall only be dedicated to supply the server room.
- The control system shall also include at the inverter's output, physical disconnection devices in case of a malfunction or fault at the controller level.
- Solar DC cables, copper conductor, halogen-free, double insulated, UV protected and fireproof, with IP67 MC4 connectors.
- DC cables between the modules and the inverters section has to be sized to limit the total voltage drop in the DC circuit to a value less than 4% of its value at rated power.
- All DC & AC wiring shall be installed so that it is mechanically and electrically sound and neat in appearance.
- DC cables shall be routed from the PV array to the junction boxes, DC protection boxes, or inverters in covered UV resistant cable trays.
- Multipolar cables with double insulation (Class II).
- AC cables between the inverters and connection have to be sized to limit the total voltage drop in the AC circuit to a value less than 3% of its value at rated power.
- The cable trays shall be hot-dip galvanized and shall be equipped with all the needed brackets, clips, junctions, and accessories for installation and fixation.
- The cutting edges and openings of cable trays and cable conduits should be cold galvanized.
- Induction loops must be avoided when cabling strings; it is highly recommended to use the skip-wiring method (also known as leap-frog) instead of the conventional daisy-chain method.
- Each string of panels has to be properly labeled with the reference and corresponding polarity, every ten (10) meters and at the input and output of cables trays, junction boxes, DC protection boxes, protection devices, or inverters.

V. Design guide for system 1

- On grid inverter

On grid inverter(s) 40kW, Huawei, GoodWe or approved equal connected in parallel mode and as mentioned in the following specs:

Efficiency: 98.7%

a) Input data

Maximum input voltage: 1100V

Max. current per MPPT: 26A

Max. short circuit current per MPPT: 40A

MPPT operating voltage range: 200V ~ 1000V

Rated input voltage: 600V

Number of inputs: 8

Number of MPPT trackers: 4

b) Output data

Rated AC active power: 40,000 W

Max. AC apparent power: 44,000 VA

Rated output current: 57.8 A

Max. Output Current: 63.8 A

c) Protection:

Input-side Disconnection Device: Yes

Anti-islanding Protection: Yes

AC Overcurrent Protection: Yes

DC Reverse-polarity Protection: Yes

PV-array String Fault Monitoring: Yes

DC Surge Arrester: Yes

AC Surge Arrester: Yes

DC Insulation Resistance Detection: Yes

Residual Current Monitoring Unit: Yes

d) Communication:

Display: LED Indicators, APP

RS485: Yes

USB: Yes

MBUS: Yes

e) General:

Operating Temperature Range: -25°C ~ 60°C

Cooling Method: Natural Convection

- Fuel save controller:

Similar to DEIF/ AGC 150 hybrid genset and PV controller

- Solar PV panels:

66 solar panels monocrystalline built with half-cut cells 550W, similar to AUSTA,

Longi, Philadelphia or approved equal and as per below specs:

Inclination required for flat roof is between 10° and 15°.

Total power from solar: 36,300Wp

Voltage at nominal peak power (V): 42.1V

Current at nominal peak power (A): 13.06A

Module efficiency: 21.28%

Number of cells: 144 (12*12)

15 years warranty on product material and workmanship

35 years warranty on linear power output

Number of panels per string: as per SLD

- Anodized aluminum structure:

Anodized aluminum 6063-T5 structure brackets, rails, clamps, all accessories' Bolts, Nuts, Washers, ... on flat roof:

Ballasted-mount type low profile for flat roofs (concrete density should be at least 250 kg/m3).

Any direct or indirect impact on the roof waterproofing, should be remediated.

The design of PV panels to take into account the spaces needed for maintenance and cleaning purposes, oriented to South and aligned with the geometry of the roof.

Direct fixation into the roof is not allowed.

Any direct or indirect impact on the roof waterproofing, should be remediated.

The design of PV panels to take into account the spaces needed for maintenance and cleaning purposes, oriented as per pitched roof and aligned with the geometry of the roof.

Solar panels' system completely with structure should be well fixed and designed to withstand wind loads as per requirements for the national standards, and it does not have any impact on the structural safety of the building.

Warranty: 10 years minimum.

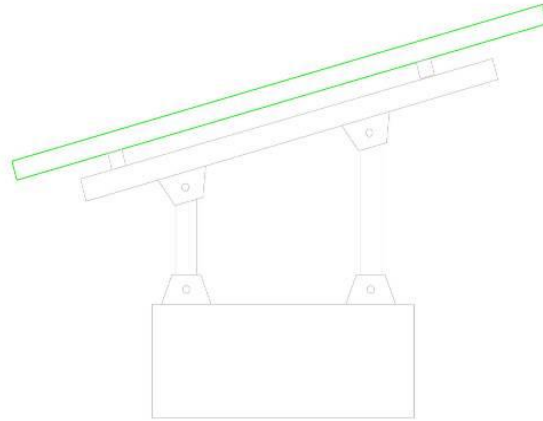


Figure 7: Aluminum structure low profile

Each panel should be installed on aluminum frame using aluminum rails and clamps at low level. Angle of inclination to be 15° . Each panel should be installed on two concrete pads.

VI. Design guide for system 2

System 2 is responsible to feed power for server room. This will require having a hybrid inverter 5KW with 6 Lithium batteries 10kWh each.

- Hybrid inverter

Hybrid inverter ON/OFF grid 5kW, one for each room scale, AUSTA, DEYE or approved equal and as per the following specs:

Nominal battery system voltage: 48VDC

- a) Inverter output:

Rated power: 5000W

Surge power: 10000VA

Waveform: pure sine wave

Inverter efficiency: 97%

- b) Solar charger & AC charger:

Maximum PV array open circuit voltage: 450VDC

Maximum PV array power: 6500W

PV array MPPT voltage range: 125~425VDC

Maximum solar charge current: 120A

Maximum AC charge current: 120A

Warranty: 5 years

- Lithium Battery:

Battery bank required is 60kWh, lithium-ion type, Felicity brand.

The specs of the battery shall be a follow:

Storage capacity: 10.24KWh

Nominal voltage: 25.6V

Nominal capacity: 200AH

Cycle life: >5000 cycles (80% DOD)

Warranty: 5 years

VII. Earthing & lightning system

The contractor is responsible for the installation of an electrical earthing system in the form of earthing rods, with a ground resistance value less than 5 ohms.

- a) EARTH ELECTRODE is to consist of one or more earth rods, interconnected by buried earthing tape or cable, which is to have a total combined resistance value, during any season of the year and before interconnection to other earthed systems or earthing means, not exceeding 3-ohm otherwise use additional earth rods. Distance between two rods is not to be less than twice the length of one rod driven depth.
- b) EARTH ROD: copper clad steel, 20 mm diameter, 4.0 m length, extendible as necessary to obtain required earth resistance. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated thereto.
- c) BURIED EARTH CONDUCTORS: annealed copper conductors 50 mm² cross-section.
- d) TAPS MATS: where earth rods are not likely to be used, earth electrode is to consist of parallel and perpendicular copper strip, 2.4 m apart, welded together by exothermic welds to form a grid.
- e) EARTH PIT: precast, square or circular section concrete hand hole (minimum 450 mm internal diameter), with concrete cover, and extending to about 150 mm below top of earth rod. Earth pit is to be provided for each earth rod connected to an earthing conductor. Cover is to have inset brass plate with inscription 'Earth Pit-Do Not Remove'.
- f) EARTHING CONDUCTORS: insulated (green/yellow) or bare copper conductor as described in the Specification for the particular application.
- g) TESTING JOINTS (TEST LINKS): copper or copper alloy, with bolted end connections, disconnectable by use of a tool, and suitably sized for earthing conductors or earth bar connection. Links are to be fixed to porcelain or other approved insulating supports. Contact surfaces are to be tinned.

- h) PROTECTIVE CONDUCTORS: single core stranded annealed copper; PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming parts of a multi-core cable, color coded.
- i) EARTHING BAR: hard drawn copper, 40x4 mm where formed into a closed loop, and 50x6 mm where open ended. Earth bar is to be labelled Main Earth Bar and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.

The contractor is responsible for the supply and installation of a complete external lightning protection system (LPS).

The contractor must keep a certain separation distance between the conductive parts of the solar PV system and the LPS, to prevent shadows, induced overvoltage, and arcing.

If separation distance cannot be maintained, the metal components of the solar PV system must be connected to the LPS through a conductor with a cross-section of at least 16mm².

The Lightning protection system should be implemented according to IEC 62305-3 and best practices for similar systems.

The ground rods of the earthing system and lightning protection system should not be bonded.

Contractor should submit detailed study and specs for earthing system before installation.

VIII. LED lighting system

- The contractor is responsible for the supply and installation of two separate lighting systems, in addition to the quantity takeoff.
- Lighting system 1: LED lighting bulbs 50W fixtures for the Court of Audit offices:
 - The bidders are responsible for the supply and installation of LED lamp retrofits for the existing lighting fixtures.
 - The proposed lamps should be compatible with the existing fixtures and equivalent in terms of luminous output.
 - The lighting level in the offices should be 500 lux at the desks level.
 - The lighting level in circulating areas such as corridors should be 100 lux.
 - The lighting level in restrooms should be 150 lux.
 - Luminous efficacy ≥ 120 lm/W
 - Color temperature 4000K
 - Nominal Lifetime ≥ 40000 h

- $CRI \geq 80$
 - Voltage input range 220V – 240V
 - Compliant with IEC 62776
- Lighting LED tubes Plug and Play 60cm in the corridor (stairs) to be verify dimemsions and number on site:
 - 400 fixtures shall be installed in the corridors (stairs) of the building.
 - Luminous efficacy $\geq 120 \text{ lm/W}$
 - Color temperature 4000K
 - Nominal Lifetime $\geq 40000\text{h}$
 - $CRI \geq 80$
 - Compliant with IEC 62776
 - Passive infrared motion sensor, power source hardwired, ceiling mounted, with a 360 degree detection angle and an adjustable time delay, standby consumption $\leq 1 \text{ W}$, rated voltage 230 V, 50 Hz, compliant with IEC 63180:2020 EN 61000-3-2 and EN 61000-3-3.

IX. Safety requirements

- The solar PV systems with battery storage shall be designed considering the safety during the construction and operation especially:
 - Safety of workers
 - Safety of users
 - Safety for the equipment of the plant
 - Safety for existing infrastructures and systems
- Any intervention on the inverters must be possible in full electrical safety.
- The contractor is responsible for the supply, installation, and tesing of the following components in the inverters/battery bank room and terrace:
 - One (1) portable powder fire extinguisher (12kg).
 - One (1) portable powder fire extinguisher (4kg).
 - One (1) Automatic powder fire extinguisher (6kg).
 - One (1) standalone smoke detector with alarm.
 - One (1) standalone Hydrogen Fluoride sensor with alarm.

X. Insurance

The contractor shall obtain and maintain insurance for the works and the qualification certificates for the various engineering procurement and construction works related to the solar PV systems. The contractor's liability insurance must feature the contract amount as a minimum cover amount per event of damage.

The proof of insurance (acknowledgement of the insurer with details about the amount, maturity, conditions and exclusions) must be submitted before the commencement of the provision of services, latest within 2 weeks before starting the work on site, and until testing and commissioning.

XI. Operation & Maintenance of solar PV system

The contractor will design, supply, build, and commission the PV system, and in general be responsible for all aspects related to the good operation of the system. The contractor shall be responsible for all aspects of the solar PV system including but not limited to, resource assessment, development, design, building, commissioning, and operation and maintenance over a period of 1 year, starting from the issuing date of the Acceptance Letter.

The contractor is responsible for providing the necessary studies and works to deliver the optimal design and construction of the systems, including: site preparation, study of the roof structures, design and study of support structures, study of the re-routing of electro-mechanical equipment, civil works, supply and installation of equipment, wiring, testing, commissioning, documentation, training, and one (1) year operation and maintenance (O&M).

The contractor shall furnish all necessary staff, supplies, materials, and equipment needed for the O&M activities.

The O&M activities will include:

- Daily remote monitoring of systems performance, alarms and diagnostics.
- Preventive maintenance.
- Corrective maintenance to take the necessary remedial measures or exchange the failed components.
- Component replacement.
- Updates of documentation where applicable.
- Reporting to the beneficiary when requested.

The preventive maintenance shall be conducted twice per year, to inspect and maintain the PV array and mounting structures, the inverters/chargers, the batteries, the remote monitoring, sensors, the wiring systems and enclosures, the connectors, the protection devices, the metallic parts, the earthing and lightning systems, in addition to the labels and signage.

- During the preventive maintenance, the contractor shall check any visual defects, discoloration, corrosion, deterioration, or mechanical damage of the components and take the suitable remedial measures in coordination with the beneficiary.
- The contractor shall make sure that there are no loose or missing panels clamps.
- The contractor shall make sure that the enclosures show no signs of internal heating and that the fuses, holders and protection devices are still intact.
- The contractor shall verify the open circuit voltage and short circuit current to make sure that the system is still functioning correctly.
- The contractor shall make sure that the labels and signage are still visible, legible, and adequately labelled.

Any proposed remedial solution has to be approved by the beneficiary, prior to taking any action on site.

XII. Testing & commissioning

- The contractor is responsible for obtaining the necessary tools and conducting the testing and commissioning of the solar PV systems with battery storage, including but not limited to the below tests.
- If the results of the tests are not compliant with the requirements of the RFP, the contractor is responsible for taking the necessary remedial measures in coordination with the beneficiary.

Final Checkouts and Visual Inspection:

- ✓ The site is clean and orderly.
- ✓ The installation matches the design documentation.
- ✓ The modules and cable routing are done properly.
- ✓ The equipment is securely mounted.
- ✓ The installations are matched to the manufacturer's specifications and recommendations.
- ✓ Warning signs and labels are posted appropriately.
- ✓ Safety equipment is installed properly.
- ✓ The installations are compliant with standards and best practices.

Mechanical Systems and Civil Works:

- ✓ Make sure that there is no rust or cracks formed in the mounting structure or foundation.
- ✓ Make sure that all clamps, nuts, and bolts are secured and tightened as per the manufacturer's recommendations, using a torque meter.

Electrical Systems:

- ✓ DC voltage test and comparison with expected voltage.
- ✓ Polarity test.
- ✓ AC voltage test at inverter output and compare to inverter datasheet.
- ✓ Open circuit test.
- ✓ Short circuit test.
- ✓ Insulation resistance test.
- ✓ Ground resistance test.
- ✓ Voltage drops tests.
- ✓ Battery bank tests.

A training of operators shall be conducted by the contractor at the end of the project, introducing the systems and explaining the different parts of the O&M manual in a power point presentation.