الجمهوريـة اللبنانيـة

وزارة الأشغال العامة والنقل

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PROJECT GENERAL DESCRIPTION

TECHNICAL SPECIFICATION FOR SOLAR PHOTOVOLTAIC SYSTEM AT THE CIVIL SERVICE COUNCIL OF LEBANON- BEIRUT

الشروط الفنية لمشروع توريد وتركيب نظام طاقة شمسية لصالح

مجلس الخدمة المدنية – بيروت

Proposed to
Port of Tripoli Website: www.oept.gov.lb Tel: +961.6.220180

Contents

I. Introduction

In a country where the sun shines around 300 days per year, there has been an enormous interest in alternative energy as a solution to electricity shortages.

The recent electrical crisis in Lebanon is the main driver of this initiative, where the national grid is suffering from long and frequent blackouts, in addition to the absence of diesel needed for the private generators owned by the Civil Service Council in Beirut, due to its expensive cost.

The port of Tripoli is looking to provide solar energy support to the Civil Service Council in Beirut to help them overcome their hardships and allow them to get back to work in normal conditions.

Project location on google maps:

https://www.google.com/maps/place/Civil+Service+Council/@33.8877023,35.4796046,17z/data=!3m1!4b1!4m5!3m4!1s0x151f172d89d7e6f7:0x2ef679773d9e09be!8m2!3d33.8876979!4d35.4817933

II. General notes and methodology

The civil Service council rents four floors in a building in Verdun, Beirut.
The mainly used offices are the first, second and third floors, while the library of the council occupies the ground floor.
Solar photovoltaic system will be divided into two parts.

System 1: The main concern of this part is a continuous electricity supply for the server's room, located on the third floor, and providing the minimum needed power for the offices to be able to operate during the Council's working hours, from 8AM till 3:30PM.
This solution requires then the presence of battery storage, as part of the solar PV system.
The suitable space to install solar panels is the roof of the building, since the parking area near the Council is mostly shaded by the high surrounding buildings.

Since the building is not owned by the Civil Service Council, the installation is not allowed on every empty space on the roof. The available space suitable to install PV panels and permitted to use is around 153 sqm.

Part 1 system potential is to produce energy from the 153sqm available space to:

- Feed the server's room during the day
- Charge the battery bank
- Supply the offices as much as possible

These targets will secure uninterruptible power supply for the minimum needs required to work in the Civil Service Council.
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.

System 2: The main concern of this part is to provide power to the common area lighting in each floor of the building, so that the residents will also benefit from the installed PV system on the common roof space. Also, to feed three projectors with motion sensors and three cameras in outdoor area.

III. System main components

The proposed solution is to be formed of solar PV panels (the maximum possible capacity in the selected area), inverter (s) (operating in both on-grid and off-grid modes to be able to benefit from the net metering scheme in the future), and a battery bank supplying the server's room during blackouts and absence of sunlight, in addition to supplying the offices' load during early hours of the morning when solar energy might not be enough to cover the load.

The inverter(s) output will then have to be connected to one fixed load in the server's room, in addition to different segregated loads on the first, second and third floors that need to be supplied by the PV system. **Some modifications should be applied in the existing electrical network inside each floor to separate the non-critical load (like air conditioners …) and to connect only critical load (server's room and computers) to the PV system**.

Lithium technology should be used for the battery bank, as this would ensure greater use of the battery capacity and a longer lifetime, compared to lead-acid batteries.

The size of each Solar PV panel should be 550W. For the available area of 153sqm, the number of panels can be 56 unit. Thus, we obtain a total of 30.8kWp PV system.

Figure 1: Available space on roof

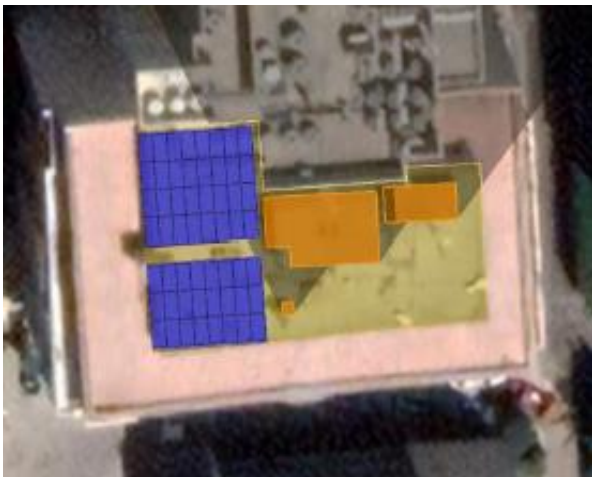

Figure 2: Top view of the proposed solution

Figure 3: Building total floors

Figure 4: West side view of the proposed solution

IV. Loads

The server's room is formed of the server, its batteries, and 2 ACs used to keep the room's temperature cool. The most used AC was consuming 2A, the rarely used one consumed around 8A. The total measured load was 22A, including all connected loads but excluding the rarely used AC. A new AC inverter type should be installed to replace the old existing AC.

The load of the server's room was obviously too high due to the amount of power needed to charge the batteries, since they were totally discharged during the long blackouts. The real load of this room, including the most used AC, is 15A, which is equivalent to 2.7kW.

The power consumption of the computers is estimated to be 200W/unit. Existing lighting fixtures should be replaced by LED fixtures to reduce the power consumption and thus, to be able to supply relevant number of fixtures from the PV system.

V. Design parameters & General notes

- Electricity supplied from EDL is considered available for 4 hours only out of 24, during which 25% of the chosen battery bank will be charged, while the 75% will be charged from the solar PV system. Any increase in feeding hours from EDL will help the PV system supply more load to offices.
- The 24 hours of electricity supply for the server's room is divided as follows: 4hours from EDL, 6 hours from the PV system directly during daylight, and 14 hours from the battery bank. In case of low irradiance, or lower EDL hours private generators shall be used to cover demand and charge batteries according to need.
- Private generators of 350Kva and 150Kva are available but not in good conditions. Contractor should repair and maintain these two generators to put them in good condition. Contractor should visit and inspect the condition of these two generators to find out how to put them in good order through a complete and general maintenance including but not limited to fuel and oil filters, separator, joints, batteries if needed, electrical panel board, control, fuel network, and make sure that all related cables, accessories, etc. are functioning correctly with synchronization with other systems.
- Working time: from 8AM to 3PM.
- Continuity of supply to the server's room is critical.
- PV panels installation is available on roof with high structure.
- Replacing the existing lighting fixtures with LED fixtures is a must to reduce Council building's consumption and increase the benefits of the solar PV system in terms of number of supplied appliances. There are around 65 offices in the Council, and most of the lighting fixtures are not LED. Therefore, there is around 260 lighting fixtures in the offices, and 40 in the corridors, resulting in total of 300 lighting fixtures that need to be replaced.
- 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 including synchronized panel.
- The contractor shall provide all necessary documents for the net-metering applications and shall assist, to a reasonably possible extent, in the application procedure.
- 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.
- The load segregation is essential in this project and the priority shall always be given to the server room at the Civil Service Council. System 1 shall be dedicated to continuously supply electricity to the server room and shall be able to feed in any additional production in energy to the sub-distribution boards at the three floors of the Council.
- System 2 shall only be dedicated to supply the lighting load in the common area in addition to the new projectors and cameras.
- Control system is required for system 1 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.
- 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.
- 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.

VI. Design guide for system 1

- Hybrid inverter compliant with net-metering

  Two hybrid inverters ON/OFF grid 20kW each, SOFAR, GoodWe, FOX ESS or approved equal, connected in parallel mode and as mentioned in the following specs:

  a) Battery input data:

  Battery type: Lead acid or Li-Ion
  Number of battery input: 2
  Battery voltage range (V): 180-800 V
  Battery voltage range for full load (V): 400-800 V
  Nominal charging/discharging power (W): 20000W
  Peak charging/discharging current, duration (A, s): 70A(35A/35A), 60s
  Charging strategy for Li-Ion battery: Self adaption to BMS
  Communication interfaces: CAN(RS485)

  b) PV string input data:

  Recommended Max. PV input power (W): 30000Wp (15000Wp/15000Wp)
  Maximum DC voltage: 1000V
  Start-up operating voltage (V): 200V
  MPPT voltage range (V): 180V-960V
  Full power MPPT voltage range (V): 450V-850V
  Max. PV input current (A): 25A+25A
  No. of MPP trackers: 2
  No. of strings per MPP tracker: 2

  c) AC output data:

  Nominal output power (W): 20000W
  Max. AC output power (W): 22000VA
  Peak output power, duration (VA, s): 22000VA, 60s
  Max. output current (A): 32A
  Peak output current, duration (A, s): 32A, 60s
  Max. continuous AC passthrough (A): 50A
  Output frequency and voltage: 50/60 Hz; 230/400Vac (three phase)
  Grid type: Three phase
  Current harmonic distortion: THD<3% @linear load
  Switch time: <20ms

  d) Efficiency:

  MPPT efficiency: 99.90%
  Euro efficiency: 97.70%

Max. efficiency: 98.20%
Max. battery charge/discharge efficiency: 97.80%

e) Protection:

DC switch: Integrated
PV reverse polarity protection: Integrated
Output over current protection: Integrated
Output over voltage protection: Integrated
Anti-islanding protection: Integrated
Residual current detection: Integrated
Insulation resistor detection: Integrated
Surge protection level: ||
Battery reverse protection: Integrated

f) General data:

Operating temperature range (℃): -30 ~ 60 ℃
Relative humidity: 0~100%
Cooling: forced airflow
Noise (dB): <45 dB
Communication with BMS: RS485; CAN
Inverter topology: Transformer less
Standby self-consumption: <15W
Protection degree: IP65
Installation style: Wall-mounted
Standard warranty: 5 years

g) Feature:

DC terminal: MC4
Grid AC terminal: 5P connector
Back-up AC terminal: 5P connector
Display: LCD display
Monitoring interfaces: Bluetooth / RS485 / WIFI / GPRS / 4G
Parallel operation: Yes

h) Certifications & standards:

EMC: EN61000-6-1, EN61000-6-3
Safety: IEC62109-1, IEC62109-2, NB-T32004/IEC62040-1
Grid: AS/NZS 4777, VDE V 0124-100, V0126-1-1, VDE-AR-N 4105, CEI 0-16/CEI 0-21, EN50549, G98/G99, UTE C15-712-1

- Solar PV panels:

  56 solar panels monocrystalline built with half-cut cells 550W, similar to AUSTA, Longi, Philadelphia or approved equal and as per below specs:
  Inclination required between 10 ° and 15 °.
  Total power from solar: 30800W
  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: 14 solar panels/ string

- Lithium Battery:

  Battery bank required is 100KWh, Felicity lithium-ion type high voltage as specified and as per below specs:
  Nominal voltage module: 51.2 V
  Nominal energy: 100kWh
  Communication: RS485
  Long cycle life energy storage battery >6000 cycles (80% DOD)
  Certification of IEC626 I 9, UN38.3, IEC62040- I, SAA etc.
  Warranty: 5 years

- Hot-Dip Galvanized HDG steel structure:
  High elevated HDG steel structure, fixed tilt type bolted, welded only where necessary.
  Hot-Dip Galvanized steel G90 (Coating Thickness: 0.9 oz/ft2) structure with protective 2 layers epoxy paint au minimum to the satisfaction of engineer on cut or welded edges. All accessories' Bolts, Nuts, Washers, … shall be stainless steel of grade SS 304.
  Solar Bracket Lock – Single (Aluminum alloy pressure side block), 35x50mm.
  Solar Bracket Lock – Double (Aluminum alloy pressure side block), 40x50mm.
  Solar Bracket Nut M8, Plastic Wing, 35x19mm.
  Slotted hot-dip galvanized steel C channel 4.1cmx4.1cm with 2mm thickness.
  Either foundation-mount or ballasted-mount types (concrete density should be at least 250 kg/m3).
  Direct fixation into the roof is not allowed.
  A**ny 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 much as possible towards the south and aligned with the geometry of the roof.
  Solar panels' system completely with structure should be well fixed, 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.

- Solar cables & cable trays:
  SOLAR DC WIRE UV RESISTANT CABLE FOR SOLAR PANEL
  Nominal Voltage 1500VDC
  Temperature rating: -40 to 90 ° C
  100% tinned cooper to minimize power loss in your solar panel system, class5 according to standards:
  EN 50618, TÜV 2 PfG 1169/08.2007, EN 50288-3-7,
  EN 60068-2-78, EN 50395
  Flame retardant to IEC/EN 60332-1-2
  Low Smoke Zero Halogen to IEC/EN 60754-1/2,
  IEC/EN 61034-1/2, EN 50267-2-2
  Ozone and UV Resistant to EN 60811-403, EN 50396, EN ISO 4892-1/3,
  Water Resistant to AD8
  Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1 or BS EN ISO 1461 and BS EN 10326 and BS EN 10327.

VII. Design guide for system 2

System 2 is for installing LED tubes in each floor of the building, equipped with motion sensors and related cables, able to provide the needed lighting during night in the common area efficiently. And to feed power to three LED projectors with motion sensors and three cameras with DVR in building surround. This will require having additional 4 PV panels to be installed on the roof and one lithium battery bank of 5kWh.

- Hybrid inverter compliant with net-metering

  One hybrid inverter ON/OFF grid 3kW Must PH pro, Austa, GoodWe or approved equal and as per the following specs:
  Nominal battery system voltage: 24VDC

  a) Inverter output:
     Rated power: 3000W
     Surge power: 6000W
     Waveform: pure sine wave
     Inverter efficiency: 90% ~ 93%

  b) Solar charger & AC charger:
     Maximum PV array open circuit voltage: 450VDC
     Maximum PV array power: 5000W
     PV array MPPT voltage range: 150~430VDC
     Maximum solar charge current: 80A
     Maximum AC charge current: 60A
     Maximum charge current: 80A
     Warranty: 2 years

- Solar PV panels:

  Four solar panels monocrystalline built with half-cut cells 550W, similar to AUSTA, Longi, Philadelphia or approved equal and as per below specs:
  Inclination required between 10 ° and 15 °.
  Total power from solar: 2180W
  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: 4 solar panels in 1 string

- Lithium Battery:
  Battery bank required is 5.12kWh, Felicity lithium-ion type as specified and as per the following specs:
  Nominal voltage: 25.6V
  Nominal capacity: 200AH
  Power: 5.12kWh
  Cycle life: >5000 cycles (80% DOD)
  Warranty: 5 years

- Hot-Dip Galvanized HDG steel structure:
  High elevated HDG steel structure, fixed tilt type bolted as system 1 ...
  Hot-Dip Galvanized steel G90 (Coating Thickness: 0.9 oz/ft2) structure with protective 2 layers epoxy paint au minimum to the satisfaction of engineer on cut or welded edges. All accessories' Bolts, Nuts, Washers, … shall be stainless steel of grade SS 304.
  Solar Bracket Lock – Single (Aluminum alloy pressure side block), 35x50mm.
  Solar Bracket Lock – Double (Aluminum alloy pressure side block), 40x50mm.
  Solar Bracket Nut M8, Plastic Wing, 35x19mm.
  Slotted hot-dip galvanized steel C channel 4.1cmx4.1cm with 2mm thickness.
  Either foundation-mount or ballasted-mount types (concrete density should be at least 250 kg/m3).
  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 much as possible towards the south and aligned with the geometry of the roof.
  Solar panels' system completely with structure should be well fixed, 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.
  System 2 must be installed on a separate mounting structure.
  Warranty: 10 years minimum

- Solar cables & cable trays:
  SOLAR DC WIRE UV RESISTANT CABLE FOR SOLAR PANEL
  Nominal Voltage 1500VDC
  Temperature rating: -40 to 90 ˚ C
  100% tinned cooper to minimize power loss in your solar panel system, class5 according to standards:
  EN 50618, TÜV 2 PfG 1169/08.2007, EN 50288-3-7,
  EN 60068-2-78, EN 50395
  Flame retardant to IEC/EN 60332-1-2
  Low Smoke Zero Halogen to IEC/EN 60754-1/2,
  IEC/EN 61034-1/2, EN 50267-2-2
  Ozone and UV Resistant to EN 60811-403, EN 50396, EN ISO 4892-1/3,
  Water Resistant to AD8
  Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1 or BS EN ISO 1461 and BS EN 10326 and BS EN 10327.
  COMPONENTS are to include cable trays, bends,
  elbows, tees, couplings and plates, rubber grommets, hangers, bracket supports and other system accessories required for safety and protection of the cable installations
  TRAYS are to be provided to carry the maximum load of cables with a factor of safety 300%.

  TRAYS are to be heavy gauge perforated sheet steel, hot-dip galvanized after manufacture, minimum 1.5 mm thick, with sides not less than 45 mm deep, and as shown on drawings. Fittings are to be same material as tray. Covers, where shown on the Drawings, are to be minimum 1.0 mm thick galvanized sheet steel, Snap-On or bolt type, forming a rigid assembly with the tray.
  GALVANIZING is to be in accordance with EN ISO 1461, applied after fabrication with local coat thickness of 45 µm and mean coat thickness of 55 µm.

VIII. 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. European brands are required.

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 handhole (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.

IX. LED lighting system

- The contractor is repsonsible for the supply and installation of two separate lighting systems, in addition to the quantity takeoff. Also to add projectors and cameras in outdoor area.
- Lighting system 1: LED fixtures for the Civil Service Council offices and corridors:
    - 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 ≥ 40000h
- CRI≥ 80
- Voltage input range 220V – 240V
- Compliant with IEC 62776

- Lighting system 2: T5 LED tubes Plug and Play 120cm:
  - 20 fixtures shall be installed in the common area in the residents section.
  - Luminous efficacy ≥ 120 lm/W
  - Color temperature 4000K
  - Nominal Lifetime ≥ 40000h
  - CRI≥ 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 ≤1 W, rated voltage 230 V, 50 Hz, compliant with IEC 63180:2020 EN 61000-3-2 and EN 61000-3-3.
- Projectors and cameras:
  - 3 LED projectors 100W with motion detection and 3 cameras with the DVR To be added on system 2. Location of projectors to be checked on site.

X. 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 (best brand), installation, and testing of the following components in the inverters/battery bank room:
  - 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.

XI. 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.

XII. 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 for monitoring and basic surveillance for at least 5 employees of the CSC, 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.

XIII. 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.
- ✓ Cut metallic edges and openings are cold galvanized.
- ✓ 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. All warranties must be submitted to the civil service council.