	PRELIMINARIES
0.01	Before pricing these Sections, the Contractor should collect all information and visit the site to inspect all related works. The Contractor shall be responsible for clearing any obstructing items on site, installing temporary direction signs, and all relevant works, taking maximum safety requirements. The Contractor should submit a plan of work and should be responsible to prepare a detailed critical path schedule of all required works. The program and the schedule shall be approved by the EMPLOYER Engineer. قبل تسعير هذه الأقسام، يجب على المقاول جمع كافة المعلومات وزيارة الموقع لتفقد جميع الأعمال ذات الصلة. يكون المقاول مسؤولاً عن إزالة أي عناصر معيقة في الموقع، وتركيب علامات الاتجاه المؤقتة، وجميع الأعمال ذات الصلة، مع مراعاة أقصى متطلبات السلامة. يجب أن يقدم المقاول خطة عمل ويجب أن يكون مسؤولاً عن إعداد جدول زمني مفصل للمسار الحرج لجميع الأعمال المطلوبة. يجب أن تتم الموافقة على البرنامج والجدول الزمني من قبل المهندس صاحب العمل.
0.02	The contractor should budget for all PPEs, protections around excavations, ladders, يجب على المقاول وضع ميزانية لجميع معدات الحماية الشخصية، والحماية حول الحفريات، والسلالم، والسقالات، والعمل على المرتفعات، وما إلى ذلك... وأي تدابير أخرى تتعلق بالصحة والسلامة والبيئة بالإضافة إلى ملصقات منع الاستغلال والانتهاك الجنسيين - منع الاستغلال الجنسي والإساءة الجنسية، جلسات التوعية والخطط والأنشطة الأخرى بما في ذلك استخدام المدخل المخصص لموظفي المقاول، وما إلى ذلك... يجب تنفيذ جميع الأنشطة في الموقع بعد اتخاذ جميع التدابير المناسبة لضمان أقصى درجات السلامة دون استثناء.
0.03	Each section referred to in the bills of quantities shall be read in conjunction with the respective section and with all other sections of specifications (Scope of Work and Technical Specifications) and contract drawings. In case of discrepancy, the most stringent يجب قراءة كل قسم مشار إليه في جداول الكميات جنباً إلى جنب مع القسم المعني ومع جميع أقسام المواصفات الأخرى (نطاق العمل والمواصفات الفنية) ورسومات العقد. في حالة وجود تناقض، تسود المعايير/المتطلبات الأكثر صرامة وتخضع لموافقة صاحب العمل.
0.04	The bills of quantities, specifications, drawings and all other contract documents are complementary to each other and form integral parts of the contract. تعتبر جداول الكميات والمواصفات والرسومات وجميع وثائق العقد الأخرى مكملة لبعضها البعض وتشكل أجزاء لا يتجزأ من العقد.
0.05	It is considered that the contractor has read the preamble prior to quoting his prices and has taken all the requirements into consideration in its pricing. ويعتبر أن المقاول قد قرأ التمهيد قبل عرض أسعاره وأخذ كافة المتطلبات بعين الاعتبار في تسعيره.
0.06	It should be understood that the unit rates of the bill of quantities items cover all needed materials, workmanship, equipment, accessories, testing and commissioning, provision of samples, preparation of drawings … etc. needed to complete and hand over the works with ينبغي أن يكون مفهوما أن معدلات الوحدة لبنود قائمة الكميات تغطي جميع المواد المطلوبة، والتصنيع، والمعدات، والملحقات، والاختبار والتشغيل، وتوفير العينات، وإعداد الرسومات ... وما إلى ذلك اللازمة لإكمال الأعمال وتسليمها مع الامتثال الكامل بمستندات العقد، سواء كانت منصوص عليها في وصف البنود أم لا.

0.07	It is the responsibility of the contractor to check the site levels, conditions and quantities of the works that should be executed in accordance with the contract drawings. تقع على عاتق المقاول مسؤولية التحقق من مناسيب الموقع وشروط وكميات الأعمال التي ينبغي تنفيذها وفقاً لرسومات العقد.
0.08	The unit rate of the materials and equipment - supplied by the contractor -should be as specified under each concerned item in the bill of quantities. يجب أن يكون معدل الوحدة للمواد والمعدات - الموردة من قبل المقاول - كما هو محدد تحت كل بند معني في جدول الكميات.
0.09	It is the responsibility of contractor to provide one set of all the workshop and six sets of As-built drawings for all disciplines for EMPLOYER review and approval in addition to soft تقع على عاتق المقاول مسؤولية توفير مجموعة واحدة من جميع ورش العمل وستة مجموعات من الرسومات المبنية لجميع التخصصات لمراجعة صاحب العمل والموافقة عليها بالإضافة إلى نسخ إلكترونية بتنسيق قابل للتنفيذ (أوتوكاد).
0.10	Contractor should provide samples of high quality and standard for EMPLOYER approval (as per specifications and drawings) before delivery and installation of material at site. يجب على المقاول تقديم عينات ذات جودة عالية ومعايير للحصول على موافقة صاحب العمل (حسب المواصفات والرسومات) قبل تسليم المواد وتركيبها في الموقع.
0.11	EMPLOYER reserves the right to increase or decrease the quantities in the Bills of Quantities up to the percentage of change specified in the Contract Conditions without any يحتفظ صاحب العمل بالحق في زيادة أو تقليل الكميات في جداول الكميات حتى نسبة التغيير المحددة في شروط العقد دون أي تغيير في سعر الوحدة أو الشروط الأخرى.
0.12	The works under this contract shall be constructed and carried out in accordance with the drawings, BOQs and latest international codes. يجب أن يتم إنشاء وتنفيذ الأعمال بموجب هذا العقد وفقاً للرسومات وجداول الكميات وأحدث الكودات الدولية.
0.13	The contractor shall provide a comprehensive training to the beneficiaries/users, as per scope of work يجب على المقاول توفير تدريب شامل للمستفيدين / المستخدمين، حسب نطاق العمل

Scope of Work and Technical Specifications

Development of Technical Specification, Supervision of Installation and Commissioning of Solar PV System in Lebanon
Al Najda Project

1. General

1.1. The Project

The objective of required services is to procure consulting services for the development of technical specification, supervision of installation and commissioning of an On-grid solar Photo Voltaic (PV) system for the Al Najda project in Koura. A 10KW Solar PV system shall be installed for this project. Implementation or execution of EE measures is not part of the current consulting assignment.

2. GLOSSARY OF TERMS

Solar photovoltaic components	
Crystalline silicon	A general category of silicon materials exhibiting a crystalline structure. Symbol: c-Si. (also single crystalline sc-Si and multi-crystalline mc-Si).
Photovoltaic module or panel	The smallest complete environmentally protected assembly of interconnected cells. Colloquially referred to as a "solar module".
Photovoltaic cell	The basic photovoltaic device. Colloquially referred to as a "solar cell".
Reference cell	A specially calibrated cell that is used to measure irradiance.
Rated capacity STC	The PV module power delivered at the maximum power point at standard test conditions (STC).
Hot spot	The intense, localized heating of a spot on a cell in a module where a breakdown of the junction on that cell has occurred due to an excessively high reverse voltage bias or by some damage. This creates a small, localized shunt path through which a large portion of the module current flows.
Bypass diode (on a module level)	A diode connected across one or more cells in the forward current direction to allow the module current to bypass cells to prevent hot spot or hot cell damage resulting from the reverse voltage biasing from the other cells in that module.
DC converter	An electronic component that changes the generator output voltage into a useable DC voltage.
Maximum power point tracking	A control strategy for DC converters and PV inverters whereby the PV generator operation is always near the point of current-voltage characteristic where the product of current and voltage yields the maximum electrical power under the operating conditions. Abbreviation: MPPT.
Inverter	A system component that converts DC electricity into AC electricity. One of the family of components that is included in "power conditioner".
String inverter	An inverter designed to operate with only one string of PV modules. The output in AC can be connected in parallel with other similar inverters.
Multi-string inverter	An inverter designed to operate with more than one string of PV modules. The output in AC can be connected in parallel with other similar inverters.
Grid-connected inverter	An inverter that is able to operate in grid-parallel with a utility supply authority.
Grid-dependent inverter	An inverter that can only operate in grid-parallel with an AC electric grid. Also known as a grid-tied inverter.

Dual mode inverter	A type of inverter that is able to operate in both autonomous and grid-parallel modes according to the availability of the utility supply authority. This type of inverter initiates autonomous operation.
Autonomous inverter	An inverter that supplies a load not connected to an electric utility. Also known as a "battery-powered inverter" or "stand-alone inverter"
Voltage control inverter	An inverter with an output voltage that is a specified sine wave produced by pulse-width modulated (PWM) control etc.
Current control inverter	An inverter with an output current that is a specified sine wave produced by pulse-width modulated (PWM) control etc.
Junction box	An enclosure in which circuits are electrically connected and where protection devices can be located.
Generator junction box	A junction box in which the photovoltaic module circuits are electrically connected and where string protection devices are located.
Utility interface disconnect switch	A switch at the interface between the photovoltaic system and the utility grid.
Storage	Accumulation of electricity in a non-electric form and which can be reconverted through the system to electricity.
Lithium ion battery	A lithium-ion (Li-ion) battery is an advanced battery technology that uses lithium ions as a key component of its electrochemistry
BESS	A Battery Emergency Storage System (BESS) is any electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its safe operating area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it
Solar photovoltaic power plants	
Distributed generation plant	The facility and equipment comprising an electricity generation plant that is interconnected to and operates in parallel with a distribution system.
Distribution system	An electrical facility and its components including poles, transformers, disconnects, isolators and wires that are operated by an electric utility to distribute electrical energy from substations to customers. Also referred to as electric grid.
Electric utility	The organization responsible for the installation, operation and maintenance of all or some portions of major electric generation, transmission, and distribution systems.
Energy and Management System	Component with the objective of ensuring the proper management of the power plant (EMS)
Genset	A colloquial term meaning “engine-generator set” consisting of an engine coupled to a rotating electric generator.
Individual electrification plant	A small electric generating system that supplies electricity to one consumption point usually from a single energy source.
Interconnection	the result of the process of electrically connecting a distributed generation plant to a distribution system in order to enable the two systems to operate in parallel with each other.
Autonomous operation	The operating mode in which loads are electrified solely by the PV plant and not in parallel with the utility. Also known as stand-alone or off-grid.
Grid-connected operation	The operating mode in which a PV plant is operating in parallel with an electric grid. Site loads will be electrified by either or both the utility or the plant. Electricity will be able to flow into the grid if the utility permits back feed operation. In the case of the present Project, grid connected operation will have a third possible source: on-site diesel generators
Photovoltaic generator	A mechanically integrated assembly of modules or panels and its support structure that forms an electricity producing sub-system. This does not include energy storage devices or power conditioners. Also known as array.
Photovoltaic string	A circuit of series-connected modules.
Photovoltaic plant	A photovoltaic generator and other components that generate and supply electricity suitable for the intended application. The component list and system configuration varies according to the application, and could also include: power conditioning, storage, system monitoring and control and utility grid interface. Also known as a photovoltaic system. Some such plants are grid-connected and large and others can also be small (micro plants), off-grid or even diesel grid connected. The following terms describe common system configurations.
Hybrid photovoltaic plant	In this Project; it is referred to a plant with: Grid, RE (this case PV) plant and Diesel generator
Multi-source photovoltaic plant	A power plant with photovoltaic generation operating in parallel with other electricity generators. In this Project it could refer to “Dual mode” “Off-grid” and "hybrid" system as all three have more than one source. Kindly refer to the function configuration section for more details
Site	The geographical location of a plant.
Sub-system	An assembly of components. The following terms describe common subsystems.
Monitor and control sub- system	The logic and control component(s) that supervise(s) the overall operation of the plant by controlling the interaction between all sub-systems.
Safety disconnect sub- system	The component(s) that monitor(s) utility grid conditions and open(s) a safety disconnect for out-of- bound conditions.

Data logging and evaluation sub-system	The measurement and logic component(s) that register and process all relevant operational parameters and data of the plant to establish the daily, monthly and annual final yields, losses and performance of the subsystems.
Solar photovoltaic plant performance parameters	
Standard test conditions (STC)	Reference values of in-plane irradiance (GI,ref = 1 000 W.m-2), air temperature (25°C), and air mass (AM = 1,5) to be used during the testing of any photovoltaic device. Abbreviation: STC.
Voltage of a photovoltaic generator	the PV generator voltage is considered to be equal to open circuit voltage under worst case conditions.
Open circuit voltage of a photovoltaic generator	The open circuit voltage at STC of a PV generator, and is equal to: VOC pvg = VOC MOD X M , where M is the number of series-connected PV modules in any PV string of the generator.
Short circuit current of a photovoltaic generator	the short circuit current at STC of a PV generator, and is equal to: ISC pvg = ISC STC MOD X Sg, where Sg is the total number of parallel-connected strings in the PV generator.
Load	An electrical component that converts electricity into a form of useful energy and only operates when voltage is applied.
Performance ratio	The overall effect of losses on an array's rated output due to array temperature, incomplete utilization of the irradiation, and system component inefficiencies or failures. Commonly found by the quotient of the final system yield over the reference yield. Symbol: PR
Yield	The equivalent amount of time that a plant would need to operate at its rated capacity at STC in order to generate the same amount of energy that it actually did generate. A yield indicates actual device or system operation normalized to its rated capacity.
Reference yield	The amount of time that the irradiance would need to be at reference irradiance levels to contribute the same incident irradiation as actually occurred. It is calculated from the quotient of the total irradiation over the reference irradiance. Symbol: Yr. NOTE: If GI,ref = 1 kW·m−2 then the irradiation as expressed in kWh·m-2 over any period of time is numerically equal to energy as expressed in kWh·kW-1 over that same period. Thus, Yr would be, in effect, "peak sun-hours" over that same period.
Final plant yield	The net energy that was supplied during a given period of time by the photovoltaic generator normalized to its rated PV capacity. Symbol: Yf.
Final annual yield	The total photovoltaic energy delivered to the load during one year per unit of installed PV capacity.
Losses	The electrical power or energy that does not result in the service that is intended for the electricity.
Normalized losses	The amount of time that a device or system would need to operate at its rated capacity in order to provide for system energy losses. These are commonly calculated from a difference in yields.
Plant rated power	Pertaining to PV autonomous plants: The power generated when connected to a rated load. Pertaining to PV grid-connected plants: The power that can be injected under standard operating conditions.
Generator rated capacity	The rated power generation of a photovoltaic generator, usually at STC.
Generator yield	The photovoltaic energy generated per unit of installed generator capacity. Also referred to as array yield. Symbol: Ya.
PV generator capture losses	The normalized losses due to photovoltaic generator operation, found by the difference between the reference yield and the generator yield. It includes mismatch losses, temperature effect and non-dispatchable yield. Symbol: Lc.
Module mismatch loss	The difference between the total maximum power of devices connected in series or parallel and the sum of each device measured separately under the same conditions. This arises because of differences in individual device I-V characteristics. Units: W or dimensionless expressed normalized.
Efficiency	The ratio of output quantity over input quantity. The quantity specified is normally the power, energy, or electric charge produced by and delivered to a component. Symbol: η is commonly used. Units: dimensionless, usually expressed as a percentage (%).
Rated efficiency	Pertaining to a device: The efficiency of a device at specified operating conditions, usually standard test conditions (STC). Pertaining to an inverter: The efficiency of an inverter when it is operating at its rated output.
State of charge	The ratio between the residual capacity and the rated capacity of a storage device. Abbreviation: SOC. Units: dimensionless, usually expressed as a percentage (%).
Partial state of charge	A state indicating that an electrical storage device has not reached a full charge. Abbreviation: PSOC. Units: dimensionless, usually expressed as a percentage (%).
Depth of discharge	A value to express the discharge of an electrical storage device. The ratio of the discharge amount to the rated capacity is generally used. Abbreviation: DOD. Units: dimensionless, usually expressed as a percentage (%).
Charging efficiency	A generic term to express ampere-hour efficiency (or less commonly, watt-hour efficiency).
Ampere-hour efficiency	The ratio of the amount of electrical charge removed during discharge conditions to the amount of electrical charge added during charge conditions in an electrical storage device.

Overload capability	Output power level beyond which permanent damage occurs to a device or system. It is expressed by the ratio of overload power to rated load power for a period of time. Units: dimensionless (usually expressed as a percentage, %), and minutes.
No load loss	Input power of the converter when its load is disconnected and output voltage is present.
Standby loss	The power drawn by a power conditioner when it is in standby mode. Units: W. Pertaining to stand- alone power conditioners: The DC. input power. Pertaining to grid-connected power conditioners: The power drawn from the utility grid.
Environmental parameters	
Ambient temperature	The temperature of the air surrounding a PV generator as measured in a vented enclosure and shielded from solar. Symbol: Tamb. Unit: °C.
Angle of incidence	The angle between the direct irradiant beam and the normal to the active surface.
Azimuth angle	The projected angle between a straight line from the apparent position of the sun to the point of observation and a horizontal line normal to the equator. This is measured from due north in the southern hemisphere and from due south in the northern hemisphere. Negative azimuth values indicate an eastern orientation and positive values a western orientation. Symbol: α.
Solar elevation angle	The angle between the direct solar beam and the horizontal plane. Symbol: θ.
Tilt angle	The angle between the horizontal plane and the plane of the module surface.
Irradiance	Electromagnetic radiated power incident upon a surface, most commonly from the sun or a solar simulator. Symbol: G. Unit: W·m-2.
Global irradiance	Irradiance on a horizontal surface. This equals horizontal direct irradiance plus horizontal diffuse irradiance.
In-plane irradiance	Total irradiance on the plane of a device. Symbol: GI.
Solar energy	Common term meaning irradiation.
Irradiation	Irradiance integrated over a specified time interval. Symbol: H. Unit: J·m-2.]
Testing and certification	
Inspection	Evaluation for conformity by measuring, observing, testing, or gauging the relevant characteristics as required by the technical specifications.
Tests	Technical operations to establish of one or more characteristics of a given product or service according to a specified procedure.
Acceptance testing	Site-specific testing to assure acceptable performance as required by the technical specifications.
Verification	Confirmation by examination and recording of physical evidence that specified requirements have been met.
Verification testing	Site-specific, periodic testing to assure continued acceptable performance.
Certificate of conformity	A label, nameplate, or document of specified form and content, directly associated with a product or service on delivery to the purchaser, attesting that the product or service is in conformity with the requirements of the certification program (e.g., with the referenced standards and specifications).
Miscellaneous	
Electromagnetic interference	The condition where electromagnetic energy interferes with the proper operation of equipment. Abbreviation: EMI.
Fuel Reduction Mode	Mode of operation when the PV plant works in parallel to the diesel genset with the objective of reducing the fuel consumption
Total harmonic distortion	The ratio of effective signal of total harmonic to effective signal of basic frequency. Units: dimensionless, usually expressed as a percentage (%).
Safe extra low voltage (SELV)	An extra-low voltage system which is electrically separated from earth and from other systems in such a way that a single fault cannot give rise to the risk of electric shock.
Extra-low voltage (ELV)	Voltage not exceeding not exceeding 50 V AC. and 120 V ripple free DC (a ripple content not exceeding 10% r.m.s). Some national standards consider 75 V DC as a maximum. In consideration of ELV status, VOC of the PV generator must be used
Low voltage.(LV)	Voltage exceeding extra-low voltage, but not exceeding 1 000 V AC. or 1 500 V DC.
High voltage (HV)	Voltage exceeding low voltage.
Double insulation	Insulation comprising both basic insulation and supplementary insulation.
Earthing	A protection against electric shocks.
ATS	Automatic transfer switch
MDB	Main Distribution Board
C/O	Change Over Switch
UG	Under Ground
PCC	Point of Common Coupling

3. 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 will be responsible of providing all Engineering, Procurement and Construction works for the optimal design and operation of the plant, including but not limited to:

- Site preparation (clearing, pruning, excavation, etc);
- All planning and permitting works required for the realization of the project;
- 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, commercial Solar PV hybrid controllers, Electric panels, etc.
- 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 small UPS system for control equipment;
- The supply and installation of equipotential bonding devices and grounding system of all metal parts of plant;
- Trees trimming if required;
- All concrete bases, foundation, and civil works necessary for the support of the system
- 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 project staff 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 he must 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, however the Beneficiary building s would provide electricity subject to rational utilization of the same by 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 Building s, 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 outdoor 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 in accordance with Appendices A and B.
- Supply and deliver spare parts as indicated in the Bill of Quantities.
- Provide the Project Sign Boards for each site as might be requested by the Employer, as well as the visibility requirements regarding labelling of equipment (Details and specifications of such labelling shall be provided by the Employer on due time during the Contract execution).
- Supply and installation of battery banks with hybrid inverter/charger system to provide around 9 hours autonomy.
- All studies, all supplies, and all work necessary to complete the works, according to the applicable laws, international standards, and best industry practice, will be provided by the Contractor.

4. SITES DETAILS

4.1. Location:

The Project is located at koura city in the north.

4.2. Environmental and Climatic Conditions

All equipment shall be fully operational in the following conditions:

- Relative humidity up to 95%
- Ambient temperature from 2ºC to 45ºC
- Urban environment with moderate presence of dust, insects, etc.
- Maximum wind speeds of 120km/h

The monthly irradiance averages included in the tables below, shall be utilized in energy yield calculations.

4.3. Earthing System

An earthing system is already existing in the facility, and earthing connections are available at the roof and other areas in the building. 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.

5. GENERAL REQUIREMENTS

The works under this Project 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.

6. 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.

6.1. PV Modules

- Solar PV panels suitable for the project purposes and local conditions;
- The module rated power should be at least 580Wp 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 21 % 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
  - 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; and

- 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;
- 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
  - 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.
- 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.

6.2. Inverters

On-grid Inverters

- On grid inverters to be provided as shown on the drawings and schedules and in the bills of quantities with at least two MPPTs, three strings inputs each, per inverter, the quoted inverters should be of the same manufacturer;
- Should be capable of synchronizing in parallel with a back-up generator in addition to EDL public Grid.
- 380V, three-phase, 50 HZ output
- MPP tracking channel wider or equal to 430 VDC-720 or larger window VDC.
- Ground connection of the inverter(s) to the equipotential bonding conductor and to the protective conductor on the AC Side;
- Insulation testing feature on DC side;

- The minimum 'European Efficiency' of the inverter shall be a minimum of 97.9%;
- Complete installation following recommendations by the manufacturer (minimum spacing, fixation, sun shed, etc.);
- Ground connection of the inverter to the equipotential bonding conductor and to the protective conductor of the AC side;
- DC fuses at both the positive (+) and the negative (-) polarity on the DC side (shall be provided in an external DC box if not possible within the inverter);
- PV specific surge arrester type 1+2 shall be provided on the DC side;
- AC Type 1+2 surge arrestor shall be provided on the AC side;
- Setting, labelling, and commissioning of inverters;
- Monitoring System – The inverters shall all be integrated in one Plant monitoring and control system, with remote monitoring capabilities;
- The PV inverter should accept control signals from the fuel save controller for power curtailment, active and reactive power control;
- Inverters shall be suitable for the Plant climatic conditions and with proven track record for similar projects; however, the supplied inverter(s) capacity shall be at a minimum temperature of 40 degrees Celsius.
- Suitable consideration of inverter ventilation to avoid potential capacity de-rating;
- Compliant to (IEC 61000-3-2 and / or IEC 61000-3-4), IEC 62109-1/2 and VDE 0126-1-1 or similar;
- Minimum warranty of 5 years

6.3. Batteries (Optional)

- Lithium iron phosphate battery banks to be provided. Cells to provide high safety and efficiency.
- Batteries should be supplied with their respective battery management system (BMS). Batteries should be installed in enclosed rack system in NEMA I case rating or higher in a dedicated location according to the manufacturer's recommendations. BMS protects the cell in all angels such as abnormal temperature, current, voltage, SoC, SoH
- All battery cables must be labelled and installed in a decent manner with the necessary routing protection to inverters or chargers.
- Batteries to have more than 6000 cycles with 95% DoD
- The contractor to choose the batteries and the invertor to be compatible.
- The battery block shall have a 48V nominal operating voltage.
- The battery shall have at least the rated capacity specified in the technical specifications at the C20 discharge rate.
- Working Temperature: 0-50 deg C
- Authentication Level VDE/IEC62619/CE/UN38.3
- Modular design with the ability to add/reduce the storage capacity easily.
- The selected supplier must have been operational on the market for at least five years

- Minimum warranty of 5 years

6.4. 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 Jacket should also be electron beam cross-linked XLPE, flame retardant, UV resistant. 6mm2 cables shall 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) overbraid 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 1000kg/100mm
    - Inherent low fire hazard
    - Excellent Corrosion resistance
    - Oil resistant
    - UV resistant
    - Provides EMC screening
    - 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 25 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 level 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 (If applicable): 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.
- For underground control cables in trenches (If applicable): 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 same or better conditions.

6.5. 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.
- Separate cable trays or conduits shall be used for LV and control / signal cables.

6.6. 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 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.
- 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.

Here is a table for the **Copper Busbar** selection of each AC panel:

BUS BAR - COPPER

Constructional details & Current carrying capacity at 35°C Amp. Temperature

SIZE in MM			AREA in Sq MM	Weight in Kg / Mtr	Current carrying capacity in Amps							
					AC (No of Bus)				DC (No of Bus)			
					I	II	III	II II	I	II	III	II II
12	X	2	24	0.209	110	200			115	205		
15	X	2	30	0.262	140	200			145	245		
15	X	3	45	0.396	170	300			175	305		
20	X	2	40	0.351	185	315			190	325		
20	X	3	60	0.529	220	380			225	390		
20	X	5	100	0.882	295	500			300	510		
25	X	3	75	0.663	270	460			275	470		
25	X	5	125	1.11	350	600			355	610		
30	X	3	90	0.796	315	540			320	560		
30	X	5	150	1.33	400	700			410	720		
40	X	3	120	1.06	420	710			430	740		
40	X	5	200	1.77	520	900			530	930		
40	X	10	400	3.55	760	1350	1850	2500	770	1400	2000	
50	X	5	250	2.22	630	1100	1650	2100	650	1150	1750	
50	X	10	500	4.44	920	1600	2250	3000	960	1700	2500	
60	X	5	300	2.66	760	1250	1760	2400	780	1300	1900	2500
60	X	10	600	5.33	1060	1900	2600	3500	1100	2000	2800	3600
80	X	5	400	3.55	970	1700	2300	3000	1000	1800	2500	3200
80	X	10	800	7.11	1380	2300	3100	4200	1450	2600	3700	4800
100	X	5	500	4.44	1200	2050	2850	3500	1250	2250	3150	4050
100	X	10	1000	8.89	1700	2800	3650	5000	1800	3200	4500	5800
120	X	10	1200	10.7	2000	3100	4100	5700	2150	3700	5200	6700
160	X	10	1600	14.2	2500	3900	5300	7300	2800	4800	6900	9000
200	X	10	2000	17.8	3000	4750	6350	8800	3400	6000	8500	10000

…

6.7. Solar diesel Controller

- The PV plant controller unit shall be a Solar hybrid controller, with a minimum track record of 4 years in operation in similar conditions.
- Shall be compatible with proposed inverters to guarantee proper operation
- The controller will continuously monitor the diesel generators (DG) output and solar inverters output via dedicated meters (independent from the GCU measurements),
- 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 hybrid solar controller shall always be maintained online even during power transfers between the different power sources and for this reason a small UPS should be supplied with it.
- Communication: RS485, Ethernet (compatible with grid connected inverter, environmental sensor and electrical meters)
- The solar Controller shall be able to perform the following functions:
  - Shall protect diesel generators and guarantee their proper operation (genset efficiency, minimum part load of 30%, spinning reserve, reverse current protection, etc.).
  - Shall be able to actively control the reactive power output from the PV inverters to keep the DG running in its optimal power factor range
  - Zero-feed into the grid when not required
  - Prevent back-feeding into the generator
  - Export extra energy produced into the grid when net meter is installed
  - Provide gradual ramp up and ramp down of PV power
  - Emergency shutdown for the PV system
  - To synchronize the PV penetration with the generator.
  - Trip the PV system at any time there is loss or interrupt of communication with the inverter
- All additional necessary accessories needed for proper functioning of the controller are to be installed and commissioned.
- Hard wired protection should be set to protect the gensets from any reverse current that might flow back from the solar system, the hardwired protection should disconnect the solar inverters via contactors controlled by a reverse current relay set at the gensets input side.
- The same protection system should operate in case of failure in communication between the solar data loggers and the soalr controller for optimal power flow protection.
- All operating parameters from the controller should be fully logged in the dedicated logger.
- Shall allow MODBUS communication for read of its registers
- Warranty : Minimum 2 years

6.8. Monitoring & Data Acquisition

The Contractor is responsible for the supply and installation of a data acquisition unit (data logger) for efficient plant operation and control and compatibility with all measuring components. All measurements are to be logged locally, and available from a remote location through an internet connection, including the data from the weather stations (optional), the inverters, the energy meters, and the solar-diesel controller.

- Optional: Supply, installation and connection of a solar technology sensors and temperature (ambient temperature + modules reference) within a weather monitoring station complete with sensors with valid calibration certificates including as a minimum (on each station):
  - 1 x Global Horizontal Irradiance pyranometers;

- 1 x Plane of Array Irradiance pyranometers;
- 1 x Shielded and ventilated ambient temperature sensors;
- 1 x module temperature sensors;
- 1 x wind speed sensors.

- Supply, installation and connection of energy meters at the injection points. The meters should measure 4 quadrant power parameters and be compatible with the solar-diesel controller.
- Provision of data acquisition software;
- The system should be capable to operate through both GSM and LAN, the Contractor should provide all accessories needed such as sim card and modules;
- A data access for remote monitoring shall be provided to the Employer and the facility operator;
- Logs of all inverter's measurements should be recorded, including at least, per inverter
  - AC power in kW
  - Reactive power in kVAr
  - Apparent power in kVA
  - Power frequency in Hz
  - Grid AC voltage in V
  - Grid AC current in A
  - DC voltage
  - DC current
  - Daily delivered energy in kWh (i.e. the energy delivered by each inverter on each calendar day).

- A UPS system should be included to power all monitoring and controller equipment. The UPS should have a 1kWh battery storage capacity and a 1000W power rating. The UPS operating voltages should be chosen according to the offered components requirements.

6.9. Dynamic Display Panel

- 50-inch TV screen and display interface for indoor use, exact location to be approved by the Employer and the building management.
- Should display at least the below data:
  - Solar penetration in %,
  - Demand load in KW
  - Genset contribution in % and in KW
  - EDL power availability
  - Running gensets indication
  - Total produced Energy (MWh),
  - Cumulative CO2 emission saved (Ton).
  - Weather data and cell temperatures
  - Alarm display page
- Graphic design considering the illustrations and texts to be approved by the Employer's Engineer.
- The Contractor will be responsible for the supply and installation of a communication device between the Plant remote monitoring system and the TV display (through LAN or other wired technology as convenient).

6.10. 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
- The PV system earthing will be connected to the existing building's earthing after performing all the required tests.

6.11. Interconnection to the Facility Grid

The interconnection to the grid shall be done as shown on the riser diagram. The main interconnection to the facility grid should be highly coordinated with the Employer and the facility, with minimum or no disturbance to the facility grid.

For any deviation from the original design regarding the different equipment location, cable lengths, or the connection point panel, the following points shall be checked and recalculated by the contractor:

The tapping point should be checked for each side to make sure that:

- The connection point panel is able to handle the solar injected capacity
- Busbar rating is able to handle the solar generation
- There will be no drawbacks on the system short circuit capability due to solar contribution
- A load flow analysis to check the system capability in terms of short circuit and voltage drop
- Minimum variation should be allowed in terms of voltage drop to be less than 2 % at the point of common coupling after PV connection.

Total system ohmic loss should be simulated and determined, the total PV internal loss from the panels to the point of common coupling should be less than 3 %

6.12. 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
- Minimum warranty of 2 years

6.13. 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 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
- Operation & Maintenance manual
- 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.
- Operation and Maintenance manuals for the Beneficiary's user and maintenance staff in English and Arabic.

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 six days. 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 PR of Plant.
  - **Annual reports** shall be prepared summarising all performance data, solar irradiation data, outages and spares data and logbooks.
  - **Status reports** after any incident on Site and/ or Plant tripping shall be also prepared.

7. STANDARDS OF PERFORMANCE

7.1. 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.

- IEC International Electrotechnical Commission.

7.2. Site Safety and Prevention of Sexual Exploitation and Abuse (PSEA)

The Contractor shall be responsible for implementing strict safety measures on site in view of the type of works being implemented and shall abide by the instructions of, guidelines and procedures to be put in place by the Employer's HSSE Officer and Project Engineer.

The Contractor shall provide and erect protection items required by site conditions and as requested by the Engineer to protect persons, onsite and offsite property, as required and as supplementary to such items that have been left in place; ascertain legal and other requirements.

The Site should always be equipped with safety kit including gloves, masks, hand gel, and thermometers, in addition to work signs, warning tapes, safety pollards or protection objects to prevent any kind of accidents. The Contractor shall also hold regular training and awareness sessions for all the staff and labour regarding any necessary health measures as recommended by the Employer or the Ministry of Public health or any other pertinent entity.

The Contractor shall maintain protection in place until work is complete and danger of damage has ceased; at such time as approved by the Engineer, remove protections.

The Contractor shall print and fix copies of the safety and safeguarding guidelines posters (In English and Arabic) on all different work areas within the site as per the pertinent HSSE guidelines and requirements. The posters' designs will be provided during the kick-off meeting.

The Contractor shall take all appropriate measures to prevent sexual harassment, exploitation or abuse of anyone by the Contractor's Personnel as stipulated in the Conditions of Contract.

The Contractor shall print and fix copies of the PSEA guidelines posters (In English and Arabic) on all different work areas within the site as per the pertinent guidelines and requirements. The posters' designs will be provided by UNIDO during the kick-off meeting.

7.3. First aid Facilities

The Contractor shall provide and maintain adequate first aid facilities on the site in accordance with the public health authorities in the Republic of Lebanon and the Lebanese Labour Code. If any accident occurs, the Contractor shall immediately notify the Employer and Engineer in writing in accordance with the pertinent HSSE guidelines and requirements.

7.4. 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.

7.5. 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.

7.6. Scheduling Requirements

The Contractor shall submit to the consultant/Engineer a work plan (schedule of works) for the project within 14 calendar days of signature of the contract. Any necessary re-submittal, subsequent planning update or adjustment should be provided within 5 calendar days from request. Failure to abide by this requirement could result in suspending any due payment under the Contract. The work plan shall be in a form and format suitable to the Engineer, and the Contractor shall be responsible for coordinating any special work plan requirements with the Engineer. As a minimum, the Programme shall be resource loaded and shall include detailed sections for submittals, procurement & delivery as well as site execution works and snagging.

The Contractor must submit a detailed breakdown planning showing item by item the duration, labours and equipment to be used.

The Contractor shall also submit a weekly schedule of the planned works mentioning the work that will be done in the following week. The Contractor shall also submit a report of the work accomplished during the preceding week.

All scheduling and planning shall be prepared through either Primavera or MS Projects.

7.7. Environmental Standards

The Contractor shall implement an environmental management plan whereby all site activities will be performed in an environmentally sound manner such as for instance considering impacts on the natural environment, water, dust and emission suppression and the proper handling and disposal of all wastes resulting from the activities undertaken under the Contract.

7.8. COVID- 19 Prevention Requirements

The Contractor must protect the health and well-being of workers in line with national measures of the Ministry of Public Health, the Ministry of Labour, and Ministry of Public Works and Transport (including the Order of Engineers and Architects). Should new national guidelines be issued, the Contractor should also take those into account. The Contractor should implement rigorous preventive measures at the workplace and site against the spread of the virus. These additional Occupational Safety and Health (OSH) measures include maintaining a minimum distance between workers at all times, the provision of protective equipment and the implementation of hygiene procedures.

These measures should be supported by awareness campaigns and information dissemination on a regular basis to the workers based on the recommendations of the Ministry of Public Health directives. The Contractor will be fully responsible to respect and implement the required guidelines and update them regularly as per the national guidelines with no additional cost or time to the Employer. The site equipment shall include as a minimum the below items on daily basis:

- Adequate hand sanitizers
- Site or medical rubber gloves
- Medical masks or face shields
- Infrared thermometers
- Soap & soap dispensers,
- Paper towels dispensers
- Disinfectants
- Site Lavatories and toilets with availability of clean water for use by all personnel/visitors
- Sign boards raising health and safety awareness on COVID 19 with a guideline including a clear contact number in case of emergency

The Contractor should provide a method statement clarifying the measures that will be applied on

site in that respect. During the implementation phase of the project, the Employer and the Engineer will have the authority, at no extra cost to the Employer, to amend and add any item/step to the approved method statement, if deemed necessary for the protection of any person present on the site premises, such as but not limited to labors, the Employer's staff, Engineer's staff, the Contractor's employees, Beneficiary, third party, subcontractors.

7.9. Social Safeguards

The Contractor is required to undertake the following social safeguards provisions for workers to ensure an appropriate application of the standards that are set forth by the laws and regulations:

- Minimum age for admission to work is 18 (Note: Although the Lebanese Labour Law allows in certain cases the employability of children under the age of 18, however, and for the purpose of this project, no children under the age of 18 are allowed to be employed for reasons related to the nature of the infrastructure work that might risk the health and safety of children.)
- Gender equality and equal employability opportunities for women. The Contractor is encouraged to have female participation, especially for skilled and management positions. (Note: The Lebanese Labour Law forbids the employers to discrimination based on gender between female and male workers in terms of type of work, salary or wage, employment, promotion, progress, professional rehabilitation and training, or dress code. A particular attention to the occupational safety and health of women in the workplace restricts the employment of women in 19 types dangerous profession as indicated by the Labour law[1].)
- Including people with disabilities in the project. The Contractor is encouraged to employ people with disabilities according to Article 74 of law number 220 /2000 on Disabled people rights, decree number 1834 on 3 December 1999[2].
- Task based wages. The Contractor should ensure that all workers, independent of their sex, ethnicity or mental or physical condition, receive the same salary for the same type of work done. The task-based payment method also facilitates the implementation of same salary for work that is of equal value.
- Induction on safety and health procedures to workers. The Contractor is required to provide safety induction training or briefing to all personnel upon starting on sites on safety, protection and health related themes. The Health and Safety Officer shall be responsible for this provision.
- First Aid kit present on site. Comprehensive and well stocked First Aid Kits shall be present

[1] The positions restricted to employ women are as follows: 1) Underground work in mines, quarries, and all stone extraction work; 2) Oven work for the melting, refining and firing of mineral products; 3) Silvering mirrors by the quicksilver process; 4) Production and handling of explosives; 5) Glass melting and firing; 6) Oxyacetylene welding; 7) Production of alcohol and all other alcoholic drinks; 8) Duco painting; 9) Handling, treatment or reduction of ashes containing lead, and de-silvering lead; 10) Production of welding material or alloys with more than ten present lead content; 11) Production of litharge, massicot, minium, white lead, mico-orange or lead sulphate, chromate or silicate, 12) Mixing and pasting operations in the production or repair work of electricity accumulators; 13) Cleaning workshops where the operations listed under No.9, 10, 11 and 12 are carried out; 14) Operating driving engines; 15) Repairing or cleaning driving engines on the run; 16) Asphalt production; 17) Tannery work; 18) Work in the warehouse of fertilizers extracted from the excrement, manure, bone and blood; and 19) Cutting up animal carcasses.

[2] The type of work and equipment, machines and devices used by the worker should be appropriate to the disability he/she holds. Below are some examples of different type of physical disabilities and the work that can be done by the respective worker according to the type of Impairment

Type of Physical disabilities	Type of work
Arm amputation	Rock shattering, gravel sieving, supervising work teams, controlling traffic.
Leg amputation	Rock shattering, gravel sieving, supervising work teams, controlling traffic, maintaining tools.
Hearing impairment or deafness	All work except for traffic control. Supervisors should inform other workers about their impairment.
Visual impairment	Many tasks. Recommend avoiding work that risks eye damage e.g. Rock shattering
Mute or communication impairment	All work. Supervisors should inform other workers about their impairment.
Intellectual disability	Many tasks that are simple to demonstrate and perform

on sites at all times, conveniently located and clearly identifiable, to ensure proper treatment to workers who get injured during the implementation of the work. Female hygiene products are recommended to be included in the Kit.

- Safety gear provided to workers. The Contractor shall provide personal protective equipment to workers, according to the work being implemented, including but are not limited to hard hats, safety glasses, gloves, safety shoes, hearing protections, or other means provided against cuts, corrosive liquids, and chemicals. The Contractor shall make sure that holes in the floor, sidewalk, or other walking surface are repaired properly, covered, or otherwise made safe.
- Access to drinking water at the workplace. The purpose of providing water is to prevent heat stress, heat stroke, hypothermia, hyperthermia and the medical condition of dehydration. These are all threats to workplace safety, especially in settings where employees may be working at very high or low temperatures, or outside. The provision of this social safeguard will be followed-up by the Health and Safety Officer.
- Provision of toilet and washing facilities at the workplace. The Contractor shall coordinate with the municipality to ensure enough toilets and washbasins for those expected to use them; where possible, separate facilities for men and women to prevent harassment; such facilities should have lockable doors and always be clean
- Provision of safety transportation. The Contractor shall ensure that safety transportation is provided to the workers from and to the work sites.

7.10. Working Hours

The Contractor shall not perform any work outside agreed site working hours unless authority to do so has been obtained in writing from the Employer or its Representative.

The Contractor shall take care to prevent disruption to existing operations in the facility and surrounding establishments.

7.11. 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 Hybrid Systems at the building Beneficiary in accordance with the pertinent regulations, especially those issued by the Ministry of Energy and Water and the Ministry of Interior Affairs. In this regard, the Contractor shall be responsible to obtain the pertinent documents from the building Beneficiary, 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.

7.12. 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.

7.13. 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.
    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.

7.14. 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.

7.15. 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	5
Lithium Battery	5
Weather station (Optional) and data loggers	2
Steel Structure	10
UPS	2

7.16. 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.
  - IEC 61215 standards for durability and performance for standard monocrystalline and polycrystalline PV module

- 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 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 Control Gear 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.
  - Underwriters Laboratories (UL)

Scope of Work and Technical Specifications

Development of Technical Specification, Supervision of Installation and Commissioning of Solar PV System in Lebanon
Al Zahraa Project

1. General

1.1. The Project

The objective of required services is to procure consulting services for the development of technical specification, supervision of installation and commissioning of a hybrid solar Photo Voltaic (PV) system with energy storage using lithium batteries for Al Zahraa Clinic Project in Tripoli Beqaa. An additional 21KW Solar PV system shall be installed for this project along with a new Lithium battery bank.. Implementation or execution of EE measures is not part of the current consulting assignment.

2. GLOSSARY OF TERMS

Solar photovoltaic components	
Crystalline silicon	A general category of silicon materials exhibiting a crystalline structure. Symbol: c-Si. (also single crystalline sc-Si and multi-crystalline mc-Si).
Photovoltaic module or panel	The smallest complete environmentally protected assembly of interconnected cells. Colloquially referred to as a "solar module".
Photovoltaic cell	The basic photovoltaic device. Colloquially referred to as a "solar cell".
Reference cell	A specially calibrated cell that is used to measure irradiance.
Rated capacity STC	The PV module power delivered at the maximum power point at standard test conditions (STC).
Hot spot	The intense, localized heating of a spot on a cell in a module where a breakdown of the junction on that cell has occurred due to an excessively high reverse voltage bias or by some damage. This creates a small, localized shunt path through which a large portion of the module current flows.
Bypass diode (on a module level)	A diode connected across one or more cells in the forward current direction to allow the module current to bypass cells to prevent hot spot or hot cell damage resulting from the reverse voltage biasing from the other cells in that module.
DC converter	An electronic component that changes the generator output voltage into a useable DC voltage.
Maximum power point tracking	A control strategy for DC converters and PV inverters whereby the PV generator operation is always near the point of current-voltage characteristic where the product of current and voltage yields the maximum electrical power under the operating conditions. Abbreviation: MPPT.
Inverter	A system component that converts DC electricity into AC electricity. One of the family of components that is included in "power conditioner".
String inverter	An inverter designed to operate with only one string of PV modules. The output in AC can be connected in parallel with other similar inverters.
Multi-string inverter	An inverter designed to operate with more than one string of PV modules. The output in AC can be connected in parallel with other similar inverters.
Grid-connected inverter	An inverter that is able to operate in grid-parallel with a utility supply authority.
Grid-dependent inverter	An inverter that can only operate in grid-parallel with an AC electric grid. Also known as a grid-tied inverter.

Dual mode inverter	A type of inverter that is able to operate in both autonomous and grid-parallel modes according to the availability of the utility supply authority. This type of inverter initiates autonomous operation.
Autonomous inverter	An inverter that supplies a load not connected to an electric utility. Also known as a "battery-powered inverter" or "stand-alone inverter"
Voltage control inverter	An inverter with an output voltage that is a specified sine wave produced by pulse-width modulated (PWM) control etc.
Current control inverter	An inverter with an output current that is a specified sine wave produced by pulse-width modulated (PWM) control etc.
Junction box	An enclosure in which circuits are electrically connected and where protection devices can be located.
Generator junction box	A junction box in which the photovoltaic module circuits are electrically connected and where string protection devices are located.
Utility interface disconnect switch	A switch at the interface between the photovoltaic system and the utility grid.
Storage	Accumulation of electricity in a non-electric form and which can be reconverted through the system to electricity.
Lithium ion battery	A lithium-ion (Li-ion) battery is an advanced battery technology that uses lithium ions as a key component of its electrochemistry
BESS	A Battery Emergency Storage System (BESS) is any electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its safe operating area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it
Solar photovoltaic power plants	
Distributed generation plant	The facility and equipment comprising an electricity generation plant that is interconnected to and operates in parallel with a distribution system.
Distribution system	An electrical facility and its components including poles, transformers, disconnects, isolators and wires that are operated by an electric utility to distribute electrical energy from substations to customers. Also referred to as electric grid.
Electric utility	The organization responsible for the installation, operation and maintenance of all or some portions of major electric generation, transmission, and distribution systems.
Energy and Management System	Component with the objective of ensuring the proper management of the power plant (EMS)
Genset	A colloquial term meaning “engine-generator set” consisting of an engine coupled to a rotating electric generator.
Individual electrification plant	A small electric generating system that supplies electricity to one consumption point usually from a single energy source.
Interconnection	the result of the process of electrically connecting a distributed generation plant to a distribution system in order to enable the two systems to operate in parallel with each other.
Autonomous operation	The operating mode in which loads are electrified solely by the PV plant and not in parallel with the utility. Also known as stand-alone or off-grid.
Grid-connected operation	The operating mode in which a PV plant is operating in parallel with an electric grid. Site loads will be electrified by either or both the utility or the plant. Electricity will be able to flow into the grid if the utility permits back feed operation. In the case of the present Project, grid connected operation will have a third possible source: on-site diesel generators
Photovoltaic generator	A mechanically integrated assembly of modules or panels and its support structure that forms an electricity producing sub-system. This does not include energy storage devices or power conditioners. Also known as array.
Photovoltaic string	A circuit of series-connected modules.
Photovoltaic plant	A photovoltaic generator and other components that generate and supply electricity suitable for the intended application. The component list and system configuration varies according to the application, and could also include: power conditioning, storage, system monitoring and control and utility grid interface. Also known as a photovoltaic system. Some such plants are grid-connected and large and others can also be small (micro plants), off-grid or even diesel grid connected. The following terms describe common system configurations.
Hybrid photovoltaic plant	In this Project; it is referred to a plant with: Grid, RE (this case PV) plant and Diesel generator
Multi-source photovoltaic plant	A power plant with photovoltaic generation operating in parallel with other electricity generators. In this Project it could refer to “Dual mode” “Off-grid” and "hybrid" system as all three have more than one source. Kindly refer to the function configuration section for more details
Site	The geographical location of a plant.
Sub-system	An assembly of components. The following terms describe common subsystems.
Monitor and control sub- system	The logic and control component(s) that supervise(s) the overall operation of the plant by controlling the interaction between all sub-systems.
Safety disconnect sub- system	The component(s) that monitor(s) utility grid conditions and open(s) a safety disconnect for out-of- bound conditions.

Data logging and evaluation sub-system	The measurement and logic component(s) that register and process all relevant operational parameters and data of the plant to establish the daily, monthly and annual final yields, losses and performance of the subsystems.
Solar photovoltaic plant performance parameters	
Standard test conditions (STC)	Reference values of in-plane irradiance (GI,ref = 1 000 W.m-2), air temperature (25°C), and air mass (AM = 1,5) to be used during the testing of any photovoltaic device. Abbreviation: STC.
Voltage of a photovoltaic generator	the PV generator voltage is considered to be equal to open circuit voltage under worst case conditions.
Open circuit voltage of a photovoltaic generator	The open circuit voltage at STC of a PV generator, and is equal to: VOC pvg = VOC MOD X M , where M is the number of series-connected PV modules in any PV string of the generator.
Short circuit current of a photovoltaic generator	the short circuit current at STC of a PV generator, and is equal to: ISC pvg = ISC STC MOD X Sg, where Sg is the total number of parallel-connected strings in the PV generator.
Load	An electrical component that converts electricity into a form of useful energy and only operates when voltage is applied.
Performance ratio	The overall effect of losses on an array's rated output due to array temperature, incomplete utilization of the irradiation, and system component inefficiencies or failures. Commonly found by the quotient of the final system yield over the reference yield. Symbol: PR
Yield	The equivalent amount of time that a plant would need to operate at its rated capacity at STC in order to generate the same amount of energy that it actually did generate. A yield indicates actual device or system operation normalized to its rated capacity.
Reference yield	The amount of time that the irradiance would need to be at reference irradiance levels to contribute the same incident irradiation as actually occurred. It is calculated from the quotient of the total irradiation over the reference irradiance. Symbol: Yr. NOTE: If GI,ref = 1 kW·m−2 then the irradiation as expressed in kWh·m-2 over any period of time is numerically equal to energy as expressed in kWh·kW-1 over that same period. Thus, Yr would be, in effect, "peak sun-hours" over that same period.
Final plant yield	The net energy that was supplied during a given period of time by the photovoltaic generator normalized to its rated PV capacity. Symbol: Yf.
Final annual yield	The total photovoltaic energy delivered to the load during one year per unit of installed PV capacity.
Losses	The electrical power or energy that does not result in the service that is intended for the electricity.
Normalized losses	The amount of time that a device or system would need to operate at its rated capacity in order to provide for system energy losses. These are commonly calculated from a difference in yields.
Plant rated power	Pertaining to PV autonomous plants: The power generated when connected to a rated load. Pertaining to PV grid-connected plants: The power that can be injected under standard operating conditions.
Generator rated capacity	The rated power generation of a photovoltaic generator, usually at STC.
Generator yield	The photovoltaic energy generated per unit of installed generator capacity. Also referred to as array yield. Symbol: Ya.
PV generator capture losses	The normalized losses due to photovoltaic generator operation, found by the difference between the reference yield and the generator yield. It includes mismatch losses, temperature effect and non-dispatchable yield. Symbol: Lc.
Module mismatch loss	The difference between the total maximum power of devices connected in series or parallel and the sum of each device measured separately under the same conditions. This arises because of differences in individual device I-V characteristics. Units: W or dimensionless expressed normalized.
Efficiency	The ratio of output quantity over input quantity. The quantity specified is normally the power, energy, or electric charge produced by and delivered to a component. Symbol: η is commonly used. Units: dimensionless, usually expressed as a percentage (%).
Rated efficiency	Pertaining to a device: The efficiency of a device at specified operating conditions, usually standard test conditions (STC). Pertaining to an inverter: The efficiency of an inverter when it is operating at its rated output.
State of charge	The ratio between the residual capacity and the rated capacity of a storage device. Abbreviation: SOC. Units: dimensionless, usually expressed as a percentage (%).
Partial state of charge	A state indicating that an electrical storage device has not reached a full charge. Abbreviation: PSOC. Units: dimensionless, usually expressed as a percentage (%).
Depth of discharge	A value to express the discharge of an electrical storage device. The ratio of the discharge amount to the rated capacity is generally used. Abbreviation: DOD. Units: dimensionless, usually expressed as a percentage (%).
Charging efficiency	A generic term to express ampere-hour efficiency (or less commonly, watt-hour efficiency).
Ampere-hour efficiency	The ratio of the amount of electrical charge removed during discharge conditions to the amount of electrical charge added during charge conditions in an electrical storage device.

Overload capability	Output power level beyond which permanent damage occurs to a device or system. It is expressed by the ratio of overload power to rated load power for a period of time. Units: dimensionless (usually expressed as a percentage, %), and minutes.
No load loss	Input power of the converter when its load is disconnected and output voltage is present.
Standby loss	The power drawn by a power conditioner when it is in standby mode. Units: W. Pertaining to stand- alone power conditioners: The DC. input power. Pertaining to grid-connected power conditioners: The power drawn from the utility grid.
Environmental parameters	
Ambient temperature	The temperature of the air surrounding a PV generator as measured in a vented enclosure and shielded from solar. Symbol: Tamb. Unit: °C.
Angle of incidence	The angle between the direct irradiant beam and the normal to the active surface.
Azimuth angle	The projected angle between a straight line from the apparent position of the sun to the point of observation and a horizontal line normal to the equator. This is measured from due north in the southern hemisphere and from due south in the northern hemisphere. Negative azimuth values indicate an eastern orientation and positive values a western orientation. Symbol: α.
Solar elevation angle	The angle between the direct solar beam and the horizontal plane. Symbol: θ.
Tilt angle	The angle between the horizontal plane and the plane of the module surface.
Irradiance	Electromagnetic radiated power incident upon a surface, most commonly from the sun or a solar simulator. Symbol: G. Unit: W·m-2.
Global irradiance	Irradiance on a horizontal surface. This equals horizontal direct irradiance plus horizontal diffuse irradiance.
In-plane irradiance	Total irradiance on the plane of a device. Symbol: GI.
Solar energy	Common term meaning irradiation.
Irradiation	Irradiance integrated over a specified time interval. Symbol: H. Unit: J·m-2.]
Testing and certification	
Inspection	Evaluation for conformity by measuring, observing, testing, or gauging the relevant characteristics as required by the technical specifications.
Tests	Technical operations to establish of one or more characteristics of a given product or service according to a specified procedure.
Acceptance testing	Site-specific testing to assure acceptable performance as required by the technical specifications.
Verification	Confirmation by examination and recording of physical evidence that specified requirements have been met.
Verification testing	Site-specific, periodic testing to assure continued acceptable performance.
Certificate of conformity	A label, nameplate, or document of specified form and content, directly associated with a product or service on delivery to the purchaser, attesting that the product or service is in conformity with the requirements of the certification program (e.g., with the referenced standards and specifications).
Miscellaneous	
Electromagnetic interference	The condition where electromagnetic energy interferes with the proper operation of equipment. Abbreviation: EMI.
Fuel Reduction Mode	Mode of operation when the PV plant works in parallel to the diesel genset with the objective of reducing the fuel consumption
Total harmonic distortion	The ratio of effective signal of total harmonic to effective signal of basic frequency. Units: dimensionless, usually expressed as a percentage (%).
Safe extra low voltage (SELV)	An extra-low voltage system which is electrically separated from earth and from other systems in such a way that a single fault cannot give rise to the risk of electric shock.
Extra-low voltage (ELV)	Voltage not exceeding not exceeding 50 V AC. and 120 V ripple free DC (a ripple content not exceeding 10% r.m.s). Some national standards consider 75 V DC as a maximum. In consideration of ELV status, VOC of the PV generator must be used
Low voltage.(LV)	Voltage exceeding extra-low voltage, but not exceeding 1 000 V AC. or 1 500 V DC.
High voltage (HV)	Voltage exceeding low voltage.
Double insulation	Insulation comprising both basic insulation and supplementary insulation.
Earthing	A protection against electric shocks.
ATS	Automatic transfer switch
MDB	Main Distribution Board
C/O	Change Over Switch
UG	Under Ground
PCC	Point of Common Coupling

3. 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 will be responsible of providing all Engineering, Procurement and Construction works for the optimal design and operation of the plant, including but not limited to:

- Site preparation (clearing, pruning, excavation, etc);
- All planning and permitting works required for the realization of the project;
- 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, commercial Solar PV hybrid controllers, Electric panels, etc.
- 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 small UPS system for control equipment;
- The supply and installation of equipotential bonding devices and grounding system of all metal parts of plant;
- Trees trimming if required;
- All concrete bases, foundation, and civil works necessary for the support of the system
- 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 project staff 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 he must 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, however the Beneficiary building s would provide electricity subject to rational utilization of the same by 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 Building s, 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 outdoor 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 in accordance with Appendices A and B.
- Supply and deliver spare parts as indicated in the Bill of Quantities.
- Provide the Project Sign Boards for each site as might be requested by the Employer, as well as the visibility requirements regarding labelling of equipment (Details and specifications of such labelling shall be provided by the Employer on due time during the Contract execution).
- Supply and installation of battery banks with hybrid inverter/charger system to provide around 9 hours autonomy.
- All studies, all supplies, and all work necessary to complete the works, according to the applicable laws, international standards, and best industry practice, will be provided by the Contractor.

4. SITES DETAILS

4.1. Location:

The Project is located in Tripoli in the north of Lebanon.

4.2. Environmental and Climatic Conditions

All equipment shall be fully operational in the following conditions:

- Relative humidity up to 95%
- Ambient temperature from 2ºC to 45ºC
- Urban environment with moderate presence of dust, insects, etc.
- Maximum wind speeds of 120km/h

The monthly irradiance averages included in the tables below, shall be utilized in energy yield calculations.

4.3. Earthing System

An earthing system is already existing in the facility, and earthing connections are available at the roof and other areas in the building. 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.

5. GENERAL REQUIREMENTS

The works under this Project 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.

6. 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.

6.1. PV Modules

- Solar PV panels suitable for the project purposes and local conditions;
- The module rated power should be at least 580Wp 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 21 % 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
  - 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; and
- 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;
- 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
  - 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 25years.
- 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.

6.2. Inverters

Hybrid Inverters

- Hybrid inverters work with batteries to store excess power as well
- Hybrid inverter shall be provided as shown on the drawings and schedules and in the bills of quantities with at least two MPPTs per inverter;
- Should be capable of charging battery banks and supply AC current from battery storage rack.
- 220V, single-phase, 50 HZ output
- Minimum of 2 MPPT
- MPP tracking channel wider or equal to 200 VDC-720 or larger window VDC.
- Battery voltage range 40-60V
- Dynamic compensation of reactive power, inverter automatic reconnection conditions, linear output power control from a third device (read and write capabilities), utility-interactive photovoltaic inverter system.

- Ground connection of the inverter(s) to the equipotential bonding conductor and to the protective conductor on the AC Side;
- Insulation testing feature on DC side;
- The minimum 'European Efficiency' of the inverter shall be a minimum of 97.9%;
- Complete installation following recommendations by the manufacturer (minimum spacing, fixation, sun shed, etc.);
- Ground connection of the inverter to the equipotential bonding conductor and to the protective conductor of the AC side;
- DC fuses on at both the positive (+) and the negative (-) polarity on the DC side (can be done in an external DC box if not possible within the inverter);
- PV specific surge arrester type 1+2 shall be provided on the DC side;
- AC Type 1+2 surge arrestor shall be provided on the AC side;
- Setting, labelling, and commissioning of inverters;
- MODBUS or CAN (with communication bridge if required), allowing reading and writing on the inverter
- Inverters shall be suitable for the Plant climatic conditions and with proven track record for similar projects; however, the supplied inverter(s) capacity shall be at a minimum temperature of 40 degrees Celsius.
- Suitable consideration of inverter ventilation to avoid potential capacity de-rating;
- Compliance to IEC/EN 61000-6-1/2/3/4, IEC/EN 62109-1, IEC/EN 62109-2
- Minimum warranty of 5 years

6.3. Batteries

- Lithium iron phosphate battery banks to be provided. Cells to provide high safety and efficiency.
- Batteries should be supplied with their respective battery management system (BMS). Batteries should be installed in enclosed rack system in NEMA I case rating or higher in a dedicated location according to the manufacturer's recommendations. BMS protects the cell in all angels such as abnormal temperature, current, voltage, SoC, SoH
- All battery cables must be labelled and installed in a decent manner with the necessary routing protection to inverters or chargers.
- Batteries to have more than 6000 cycles with 95% DoD
- The contractor to choose the batteries and the invertor to be compatible.
- The battery block shall have a 48V nominal operating voltage.
- The battery shall have at least the rated capacity specified in the technical specifications at the C20 discharge rate.
- Working Temperature: 0-50 deg C
- Authentication Level VDE/IEC62619/CE/UN38.3
- Modular design with the ability to add/reduce the storage capacity easily.
- The selected supplier must have been operational on the market for at least five years
- Minimum warranty of 5 years

6.4. 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 Jacket should also be electron beam cross-linked XLPE, flame retardant, UV resistant. 6mm2 cables shall 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) overbraid 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 1000kg/100mm
    - Inherent low fire hazard
    - Excellent Corrosion resistance
    - Oil resistant
    - UV resistant
    - Provides EMC screening
    - Offers Antistatic properties

- The maximum allowed DC Voltage drop is 3%.
- 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 Jacket should also be electron beam cross-linked XLPE, flame retardant, UV resistant. 4mm2 and 6mm2 cables can be used.
- AC Cables shall have the following properties:

    - Multi-Core PVC Insulated Cables (0.6/1 kV): To have annealed, copper conductors, compacted, insulated with PVC to IEC 60227, and conductor temperatures of 70 deg. C. Armoured cables are to have single layer of galvanized steel wire armour. Cables are to comply with IEC 60502.

- ABC Cables (0.6/1 kV): ABC cables shall be compliant with BS 7870-5, HD 626 S1, EN 60228 or NFC 33-209.

  The compressed, stranded conductors of aluminium, with a cross sectional area above 95mm² shall have at least 15 strands. The insulated messenger wire cable shall consist of three black, weather resistant, cross-linked polyethylene insulated AAAC conductors (All Aluminium Alloy Conductors) twisted around an insulated aluminium alloy.

  The cable shall have a symmetrical right hand lay with a length of lay of about 40 times the diameter over the cores, laid up. In addition, the pitch of laying shall be such as to allow easy separation of conductors when making connection but also maintain the bundle cohesion in line angles. The cores shall be of the same length and lie close to each other.

  All conductors shall be constructed to IEC 61089. The properties of the Aluminium wires before stranding shall be as below.

Tensile strength not less than	90 N/mm2
Resistivity at 20°C not exceeding	0.02845 ohm/mm²/m

  The messenger shall be an All-Aluminium-Alloy conductor composed of wires drawn from rod, which is manufactured in a continuous casting and rolling procedure. The properties for the individual wires before stranding shall be:

Tensile strength not less than	278 N/mm²
Resistivity at 20°C not exceeding	0.0328 ohm/mm²/m
Density at 20°C	2.7 kg/m³

  No joints are allowed in the messenger except those made on the base rod or wire before final drawing. The messenger shall be round, stranded and compacted to have smooth round surface. The messenger takes all the mechanical stress and also serves as a neutral conductor.

- 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 25 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 level 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 (If applicable): 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.
- For underground control cables in trenches (If applicable): 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 same or better conditions.

6.5. 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.
- Separate cable trays or conduits shall be used for LV and control / signal cables.

6.6. 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 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.

- 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.

Here is a table for the **Copper Busbar** selection of each AC panel:

BUS BAR - COPPER

Constructional details & Current carrying capacity at 35°C Amp. Temperature

SIZE in MM			AREA in Sq MM	Weight in Kg / Mtr	Current carrying capacity in Amps							
					AC (No of Bus)				DC (No of Bus)			
					I	II	III	II II	I	II	III	II II
12	X	2	24	0.209	110	200			115	205		
15	X	2	30	0.262	140	200			145	245		
15	X	3	45	0.396	170	300			175	305		
20	X	2	40	0.351	185	315			190	325		
20	X	3	60	0.529	220	380			225	390		
20	X	5	100	0.882	295	500			300	510		
25	X	3	75	0.663	270	460			275	470		
25	X	5	125	1.11	350	600			355	610		
30	X	3	90	0.796	315	540			320	560		
30	X	5	150	1.33	400	700			410	720		
40	X	3	120	1.06	420	710			430	740		
40	X	5	200	1.77	520	900			530	930		
40	X	10	400	3.55	760	1350	1850	2500	770	1400	2000	
50	X	5	250	2.22	630	1100	1650	2100	650	1150	1750	
50	X	10	500	4.44	920	1600	2250	3000	960	1700	2500	
60	X	5	300	2.66	760	1250	1760	2400	780	1300	1900	2500
60	X	10	600	5.33	1060	1900	2600	3500	1100	2000	2800	3600
80	X	5	400	3.55	970	1700	2300	3000	1000	1800	2500	3200
80	X	10	800	7.11	1380	2300	3100	4200	1450	2600	3700	4800
100	X	5	500	4.44	1200	2050	2850	3500	1250	2250	3150	4050
100	X	10	1000	8.89	1700	2800	3650	5000	1800	3200	4500	5800
120	X	10	1200	10.7	2000	3100	4100	5700	2150	3700	5200	6700
160	X	10	1600	14.2	2500	3900	5300	7300	2800	4800	6900	9000
200	X	10	2000	17.8	3000	4750	6350	8800	3400	6000	8500	10000

…

6.7. Monitoring & Data Acquisition (OPTIONAL)

The Contractor is responsible for the supply and installation of a data acquisition unit (data logger) for efficient plant operation and control and compatibility with all measuring components. All measurements are to be logged locally, and available from a remote location through an internet connection, including the data from the weather stations (optional), the inverters, the energy meters, and the solar-diesel controller.

- Optional: Supply, installation and connection of a solar technology sensors and temperature (ambient temperature + modules reference) within a weather monitoring station complete with sensors with valid calibration certificates including as a minimum (on each station):
  - 1 x Global Horizontal Irradiance pyranometers;
  - 1 x Plane of Array Irradiance pyranometers;
  - 1 x Shielded and ventilated ambient temperature sensors;
  - 1 x module temperature sensors;
  - 1 x wind speed sensors.

- Supply, installation and connection of energy meters at the injection points. The meters should measure 4 quadrant power parameters and be compatible with the solar-diesel controller.
- Provision of data acquisition software;
- The system should be capable to operate through both GSM and LAN, the Contractor should provide all accessories needed such as sim card and modules;
- A data access for remote monitoring shall be provided to the Employer and the facility operator;
- Logs of all inverter's measurements should be recorded, including at least, per inverter
  - AC power in kW
  - Reactive power in kVAr
  - Apparent power in kVA
  - Power frequency in Hz
  - Grid AC voltage in V
  - Grid AC current in A
  - DC voltage
  - DC current
  - Daily delivered energy in kWh (i.e. the energy delivered by each inverter on each calendar day).

- A UPS system should be included to power all monitoring and controller equipment. The UPS should have a 1kWh battery storage capacity and a 1000W power rating. The UPS operating voltages should be chosen according to the offered components requirements.

6.8. Dynamic Display Panel (OPTIONAL)

- 50-inch TV screen and display interface for indoor use, exact location to be approved by the Employer and the building management.
- Should display at least the below data:
  - Solar penetration in %,
  - Demand load in KW
  - Genset contribution in % and in KW
  - EDL power availability
  - Running gensets indication
  - Total produced Energy (MWh),
  - Cumulative CO2 emission saved (Ton).
  - Weather data and cell temperatures
  - Alarm display page
- Graphic design considering the illustrations and texts to be approved by the Employer's Engineer.

- The Contractor will be responsible for the supply and installation of a communication device between the Plant remote monitoring system and the TV display (through LAN or other wired technology as convenient).

6.9. 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
- The PV system earthing will be connected to the existing building's earthing after performing all the required tests.

6.10. Interconnection to the Facility Grid

The interconnection to the grid shall be done as shown on the riser diagram. The main interconnection to the facility grid should be highly coordinated with the Employer and the facility, with minimum or no disturbance to the facility grid.

For any deviation from the original design regarding the different equipment location, cable lengths, or the connection point panel, the following points shall be checked and recalculated by the contractor:

The tapping point should be checked for each side to make sure that:

- The connection point panel is able to handle the solar injected capacity
- Busbar rating is able to handle the solar generation
- There will be no drawbacks on the system short circuit capability due to solar contribution
- A load flow analysis to check the system capability in terms of short circuit and voltage drop
- Minimum variation should be allowed in terms of voltage drop to be less than 2 % at the point of common coupling after PV connection.

Total system ohmic loss should be simulated and determined, the total PV internal loss from the panels to the point of common coupling should be less than 3 %

6.11. 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
- Minimum warranty of 2 years

6.12. 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 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
- Operation & Maintenance manual
- 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.
- Operation and Maintenance manuals for the Beneficiary's user and maintenance staff in English and Arabic.

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 six days. 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 PR of Plant.
  - **Annual reports** shall be prepared summarising all performance data, solar irradiation data, outages and spares data and logbooks.
  - **Status reports** after any incident on Site and/ or Plant tripping shall be also prepared.

7. STANDARDS OF PERFORMANCE

7.1. 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.
- IEC International Electrotechnical Commission.

7.2. Site Safety and Prevention of Sexual Exploitation and Abuse (PSEA)

The Contractor shall be responsible for implementing strict safety measures on site in view of the type of works being implemented and shall abide by the instructions of, guidelines and procedures to be put in place by the Employer's HSSE Officer and Project Engineer.

The Contractor shall provide and erect protection items required by site conditions and as requested by the Engineer to protect persons, onsite and offsite property, as required and as supplementary to such items that have been left in place; ascertain legal and other requirements.

The Site should always be equipped with safety kit including gloves, masks, hand gel, and thermometers, in addition to work signs, warning tapes, safety pollards or protection objects to prevent any kind of accidents. The Contractor shall also hold regular training and awareness sessions for all the staff and labour regarding any necessary health measures as recommended by the Employer or the Ministry of Public health or any other pertinent entity.

The Contractor shall maintain protection in place until work is complete and danger of damage has ceased; at such time as approved by the Engineer, remove protections.

The Contractor shall print and fix copies of the safety and safeguarding guidelines posters (In English and Arabic) on all different work areas within the site as per the pertinent HSSE guidelines and requirements. The posters' designs will be provided during the kick-off meeting.

The Contractor shall take all appropriate measures to prevent sexual harassment, exploitation or abuse of anyone by the Contractor's Personnel as stipulated in the Conditions of Contract.

The Contractor shall print and fix copies of the PSEA guidelines posters (In English and Arabic) on all different work areas within the site as per the pertinent guidelines and requirements. The posters' designs will be provided by UNIDO during the kick-off meeting.

7.3. First aid Facilities

The Contractor shall provide and maintain adequate first aid facilities on the site in accordance with the public health authorities in the Republic of Lebanon and the Lebanese Labour Code. If any accident occurs, the Contractor shall immediately notify the Employer and Engineer in writing in accordance with the pertinent HSSE guidelines and requirements.

7.4. 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.

7.5. 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.

7.6. Scheduling Requirements

The Contractor shall submit to the consultant/Engineer a work plan (schedule of works) for the project within 14 calendar days of signature of the contract. Any necessary re-submittal, subsequent planning update or adjustment should be provided within 5 calendar days from request. Failure to abide by this requirement could result in suspending any due payment under the Contract. The work plan shall be in a form and format suitable to the Engineer, and the Contractor shall be responsible for coordinating any special work plan requirements with the Engineer. As a minimum, the Programme shall be resource loaded and shall include detailed sections for submittals, procurement & delivery as well as site execution works and snagging.

The Contractor must submit a detailed breakdown planning showing item by item the duration, labours and equipment to be used.

The Contractor shall also submit a weekly schedule of the planned works mentioning the work that will be done in the following week. The Contractor shall also submit a report of the work accomplished during the preceding week.

All scheduling and planning shall be prepared through either Primavera or MS Projects.

7.7. Environmental Standards

The Contractor shall implement an environmental management plan whereby all site activities will be performed in an environmentally sound manner such as for instance considering impacts on the natural environment, water, dust and emission suppression and the proper handling and disposal of all wastes resulting from the activities undertaken under the Contract.

7.8. COVID- 19 Prevention Requirements

The Contractor must protect the health and well-being of workers in line with national measures of the Ministry of Public Health, the Ministry of Labour, and Ministry of Public Works and Transport (including the Order of Engineers and Architects). Should new national guidelines be issued, the Contractor should also take those into account. The Contractor should implement rigorous preventive measures at the workplace and site against the spread of the virus. These additional Occupational Safety and Health (OSH) measures include maintaining a minimum distance between workers at all times, the provision of protective equipment and the implementation of hygiene procedures.

These measures should be supported by awareness campaigns and information dissemination on a regular basis to the workers based on the recommendations of the Ministry of Public Health directives. The Contractor will be fully responsible to respect and implement the required guidelines and update them regularly as per the national guidelines with no additional cost or time to the Employer. The site equipment shall include as a minimum the below items on daily basis:

- Adequate hand sanitizers
- Site or medical rubber gloves

- Medical masks or face shields
- Infrared thermometers
- Soap & soap dispensers,
- Paper towels dispensers
- Disinfectants
- Site Lavatories and toilets with availability of clean water for use by all personnel/visitors
- Sign boards raising health and safety awareness on COVID 19 with a guideline including a clear contact number in case of emergency

The Contractor should provide a method statement clarifying the measures that will be applied on site in that respect. During the implementation phase of the project, the Employer and the Engineer will have the authority, at no extra cost to the Employer, to amend and add any item/step to the approved method statement, if deemed necessary for the protection of any person present on the site premises, such as but not limited to labors, the Employer's staff, Engineer's staff, the Contractor's employees, Beneficiary, third party, subcontractors.

7.9. Social Safeguards

The Contractor is required to undertake the following social safeguards provisions for workers to ensure an appropriate application of the standards that are set forth by the laws and regulations:

- Minimum age for admission to work is 18 (Note: Although the Lebanese Labour Law allows in certain cases the employability of children under the age of 18, however, and for the purpose of this project, no children under the age of 18 are allowed to be employed for reasons related to the nature of the infrastructure work that might risk the health and safety of children.)
- Gender equality and equal employability opportunities for women. The Contractor is encouraged to have female participation, especially for skilled and management positions. (Note: The Lebanese Labour Law forbids the employers to discrimination based on gender between female and male workers in terms of type of work, salary or wage, employment, promotion, progress, professional rehabilitation and training, or dress code. A particular attention to the occupational safety and health of women in the workplace restricts the employment of women in 19 types dangerous profession as indicated by the Labour law[1].)
- Including people with disabilities in the project. The Contractor is encouraged to employ people with disabilities according to Article 74 of law number 220 /2000 on Disabled people rights, decree number 1834 on 3 December 1999[2].

[1] The positions restricted to employ women are as follows: 1) Underground work in mines, quarries, and all stone extraction work; 2) Oven work for the melting, refining and firing of mineral products; 3) Silvering mirrors by the quicksilver process; 4) Production and handling of explosives; 5) Glass melting and firing; 6) Oxyacetylene welding; 7) Production of alcohol and all other alcoholic drinks; 8) Duco painting; 9) Handling, treatment or reduction of ashes containing lead, and de-silvering lead; 10) Production of welding material or alloys with more than ten present lead content; 11) Production of litharge, massicot, minium, white lead, mico-orange or lead sulphate, chromate or silicate, 12) Mixing and pasting operations in the production or repair work of electricity accumulators; 13) Cleaning workshops where the operations listed under No.9, 10, 11 and 12 are carried out; 14) Operating driving engines; 15) Repairing or cleaning driving engines on the run; 16) Asphalt production; 17) Tannery work; 18) Work in the warehouse of fertilizers extracted from the excrement, manure, bone and blood; and 19) Cutting up animal carcasses.

[2] The type of work and equipment, machines and devices used by the worker should be appropriate to the disability he/she holds. Below are some examples of different type of physical disabilities and the work that can be done by the respective worker according to the type of Impairment
Type of Physical disabilities
Type of work
Arm amputation
Rock shattering, gravel sieving, supervising work teams, controlling traffic.
Leg amputation
Rock shattering, gravel sieving, supervising work teams, controlling traffic, maintaining tools.
Hearing impairment or deafness
All work except for traffic control. Supervisors should inform other workers about their impairment.
Visual impairment
Many tasks. Recommend avoiding work that risks eye damage e.g. Rock shattering
Mute or communication impairment
All work. Supervisors should inform other workers about their impairment.
Intellectual disability
Many tasks that are simple to demonstrate and perform

- Task based wages. The Contractor should ensure that all workers, independent of their sex, ethnicity or mental or physical condition, receive the same salary for the same type of work done. The task-based payment method also facilitates the implementation of same salary for work that is of equal value.
- Induction on safety and health procedures to workers. The Contractor is required to provide safety induction training or briefing to all personnel upon starting on sites on safety, protection and health related themes. The Health and Safety Officer shall be responsible for this provision.
- First Aid kit present on site. Comprehensive and well stocked First Aid Kits shall be present on sites at all times, conveniently located and clearly identifiable, to ensure proper treatment to workers who get injured during the implementation of the work. Female hygiene products are recommended to be included in the Kit.
- Safety gear provided to workers. The Contractor shall provide personal protective equipment to workers, according to the work being implemented, including but are not limited to hard hats, safety glasses, gloves, safety shoes, hearing protections, or other means provided against cuts, corrosive liquids, and chemicals. The Contractor shall make sure that holes in the floor, sidewalk, or other walking surface are repaired properly, covered, or otherwise made safe.
- Access to drinking water at the workplace. The purpose of providing water is to prevent heat stress, heat stroke, hypothermia, hyperthermia and the medical condition of dehydration. These are all threats to workplace safety, especially in settings where employees may be working at very high or low temperatures, or outside. The provision of this social safeguard will be followed-up by the Health and Safety Officer.
- Provision of toilet and washing facilities at the workplace. The Contractor shall coordinate with the municipality to ensure enough toilets and washbasins for those expected to use them; where possible, separate facilities for men and women to prevent harassment; such facilities should have lockable doors and always be clean
- Provision of safety transportation. The Contractor shall ensure that safety transportation is provided to the workers from and to the work sites.

7.10. Working Hours

The Contractor shall not perform any work outside agreed site working hours unless authority to do so has been obtained in writing from the Employer or its Representative.

The Contractor shall take care to prevent disruption to existing operations in the facility and surrounding establishments.

7.11. 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 Hybrid Systems at the building Beneficiary in accordance with the pertinent regulations, especially those issued by the Ministry of Energy and Water and the Ministry of Interior Affairs. In this regard, the Contractor shall be responsible to obtain the pertinent documents from the building Beneficiary, 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.

7.12. 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.

7.13. 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.
    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.

7.14. 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.

7.15. 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	5
Lithium Battery	5
Weather station (Optional) and data loggers	2
Steel Structure	10
UPS	2

7.16. 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.
    - IEC 61215 standards for durability and performance for standard monocrystalline and polycrystalline PV module

- 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 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 Control Gear 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.
  - Underwriters Laboratories (UL)

Scope of Work and Technical Specifications

Development of Technical Specification, Supervision of Installation and Commissioning of Solar PV System in Lebanon Osanam Project

1. General

1.1. The Project

The objective of required services is to procure consulting services for the development of technical specification, supervision of installation and commissioning of a solar Photo Voltaic (PV) system with energy storage using lithium batteries for Ozanam Project in Batroun. Four nos Solar PV panels for a water heating system shall be installed for this project along with a new Lithum battery bank of 160KWH. The existing batteries shall be used as a back-up through a manual transfer switch in order not to mix the new batteries with old ones. Implementation or execution of EE measures is not part of the current consulting assignment.

2. GLOSSARY OF TERMS

Solar photovoltaic components	
Crystalline silicon	A general category of silicon materials exhibiting a crystalline structure. Symbol: c-Si. (also single crystalline sc-Si and multi-crystalline mc-Si).
Photovoltaic module or panel	The smallest complete environmentally protected assembly of interconnected cells. Colloquially referred to as a "solar module".
Photovoltaic cell	The basic photovoltaic device. Colloquially referred to as a "solar cell".
Reference cell	A specially calibrated cell that is used to measure irradiance.
Rated capacity STC	The PV module power delivered at the maximum power point at standard test conditions (STC).
Hot spot	The intense, localized heating of a spot on a cell in a module where a breakdown of the junction on that cell has occurred due to an excessively high reverse voltage bias or by some damage. This creates a small, localized shunt path through which a large portion of the module current flows.
Bypass diode (on a module level)	A diode connected across one or more cells in the forward current direction to allow the module current to bypass cells to prevent hot spot or hot cell damage resulting from the reverse voltage biasing from the other cells in that module.
DC converter	An electronic component that changes the generator output voltage into a useable DC voltage.
Maximum power point tracking	A control strategy for DC converters and PV inverters whereby the PV generator operation is always near the point of current-voltage characteristic where the product of current and voltage yields the maximum electrical power under the operating conditions. Abbreviation: MPPT.
Inverter	A system component that converts DC electricity into AC electricity. One of the family of components that is included in "power conditioner".
String inverter	An inverter designed to operate with only one string of PV modules. The output in AC can be connected in parallel with other similar inverters.
Multi-string inverter	An inverter designed to operate with more than one string of PV modules. The output in AC can be connected in parallel with other similar inverters.
Grid-connected inverter	An inverter that is able to operate in grid-parallel with a utility supply authority.
Grid-dependent inverter	An inverter that can only operate in grid-parallel with an AC electric grid. Also known as a grid-tied inverter.

Dual mode inverter	A type of inverter that is able to operate in both autonomous and grid-parallel modes according to the availability of the utility supply authority. This type of inverter initiates autonomous operation.
Autonomous inverter	An inverter that supplies a load not connected to an electric utility. Also known as a "battery-powered inverter" or "stand-alone inverter"
Voltage control inverter	An inverter with an output voltage that is a specified sine wave produced by pulse-width modulated (PWM) control etc.
Current control inverter	An inverter with an output current that is a specified sine wave produced by pulse-width modulated (PWM) control etc.
Junction box	An enclosure in which circuits are electrically connected and where protection devices can be located.
Generator junction box	A junction box in which the photovoltaic module circuits are electrically connected and where string protection devices are located.
Utility interface disconnect switch	A switch at the interface between the photovoltaic system and the utility grid.
Storage	Accumulation of electricity in a non-electric form and which can be reconverted through the system to electricity.
Lithium ion battery	A lithium-ion (Li-ion) battery is an advanced battery technology that uses lithium ions as a key component of its electrochemistry
BESS	A Battery Emergency Storage System (BESS) is any electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its safe operating area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it
Solar photovoltaic power plants	
Distributed generation plant	The facility and equipment comprising an electricity generation plant that is interconnected to and operates in parallel with a distribution system.
Distribution system	An electrical facility and its components including poles, transformers, disconnects, isolators and wires that are operated by an electric utility to distribute electrical energy from substations to customers. Also referred to as electric grid.
Electric utility	The organization responsible for the installation, operation and maintenance of all or some portions of major electric generation, transmission, and distribution systems.
Energy and Management System	Component with the objective of ensuring the proper management of the power plant (EMS)
Genset	A colloquial term meaning “engine-generator set” consisting of an engine coupled to a rotating electric generator.
Individual electrification plant	A small electric generating system that supplies electricity to one consumption point usually from a single energy source.
Interconnection	the result of the process of electrically connecting a distributed generation plant to a distribution system in order to enable the two systems to operate in parallel with each other.
Autonomous operation	The operating mode in which loads are electrified solely by the PV plant and not in parallel with the utility. Also known as stand-alone or off-grid.
Grid-connected operation	The operating mode in which a PV plant is operating in parallel with an electric grid. Site loads will be electrified by either or both the utility or the plant. Electricity will be able to flow into the grid if the utility permits back feed operation. In the case of the present Project, grid connected operation will have a third possible source: on-site diesel generators
Photovoltaic generator	A mechanically integrated assembly of modules or panels and its support structure that forms an electricity producing sub-system. This does not include energy storage devices or power conditioners. Also known as array.
Photovoltaic string	A circuit of series-connected modules.
Photovoltaic plant	A photovoltaic generator and other components that generate and supply electricity suitable for the intended application. The component list and system configuration varies according to the application, and could also include: power conditioning, storage, system monitoring and control and utility grid interface. Also known as a photovoltaic system. Some such plants are grid-connected and large and others can also be small (micro plants), off-grid or even diesel grid connected. The following terms describe common system configurations.
Hybrid photovoltaic plant	In this Project; it is referred to a plant with: Grid, RE (this case PV) plant and Diesel generator
Multi-source photovoltaic plant	A power plant with photovoltaic generation operating in parallel with other electricity generators. In this Project it could refer to “Dual mode” “Off-grid” and "hybrid" system as all three have more than one source. Kindly refer to the function configuration section for more details
Site	The geographical location of a plant.
Sub-system	An assembly of components. The following terms describe common subsystems.
Monitor and control sub- system	The logic and control component(s) that supervise(s) the overall operation of the plant by controlling the interaction between all sub-systems.
Safety disconnect sub- system	The component(s) that monitor(s) utility grid conditions and open(s) a safety disconnect for out-of- bound conditions.

Data logging and evaluation sub-system	The measurement and logic component(s) that register and process all relevant operational parameters and data of the plant to establish the daily, monthly and annual final yields, losses and performance of the subsystems.
Solar photovoltaic plant performance parameters	
Standard test conditions (STC)	Reference values of in-plane irradiance (GI,ref = 1 000 W.m-2), air temperature (25°C), and air mass (AM = 1,5) to be used during the testing of any photovoltaic device. Abbreviation: STC.
Voltage of a photovoltaic generator	the PV generator voltage is considered to be equal to open circuit voltage under worst case conditions.
Open circuit voltage of a photovoltaic generator	The open circuit voltage at STC of a PV generator, and is equal to: VOC pvg = VOC MOD X M , where M is the number of series-connected PV modules in any PV string of the generator.
Short circuit current of a photovoltaic generator	the short circuit current at STC of a PV generator, and is equal to: ISC pvg = ISC STC MOD X Sg, where Sg is the total number of parallel-connected strings in the PV generator.
Load	An electrical component that converts electricity into a form of useful energy and only operates when voltage is applied.
Performance ratio	The overall effect of losses on an array's rated output due to array temperature, incomplete utilization of the irradiation, and system component inefficiencies or failures. Commonly found by the quotient of the final system yield over the reference yield. Symbol: PR
Yield	The equivalent amount of time that a plant would need to operate at its rated capacity at STC in order to generate the same amount of energy that it actually did generate. A yield indicates actual device or system operation normalized to its rated capacity.
Reference yield	The amount of time that the irradiance would need to be at reference irradiance levels to contribute the same incident irradiation as actually occurred. It is calculated from the quotient of the total irradiation over the reference irradiance. Symbol: Yr. NOTE: If GI,ref = 1 kW·m−2 then the irradiation as expressed in kWh·m-2 over any period of time is numerically equal to energy as expressed in kWh·kW-1 over that same period. Thus, Yr would be, in effect, "peak sun-hours" over that same period.
Final plant yield	The net energy that was supplied during a given period of time by the photovoltaic generator normalized to its rated PV capacity. Symbol: Yf.
Final annual yield	The total photovoltaic energy delivered to the load during one year per unit of installed PV capacity.
Losses	The electrical power or energy that does not result in the service that is intended for the electricity.
Normalized losses	The amount of time that a device or system would need to operate at its rated capacity in order to provide for system energy losses. These are commonly calculated from a difference in yields.
Plant rated power	Pertaining to PV autonomous plants: The power generated when connected to a rated load. Pertaining to PV grid-connected plants: The power that can be injected under standard operating conditions.
Generator rated capacity	The rated power generation of a photovoltaic generator, usually at STC.
Generator yield	The photovoltaic energy generated per unit of installed generator capacity. Also referred to as array yield. Symbol: Ya.
PV generator capture losses	The normalized losses due to photovoltaic generator operation, found by the difference between the reference yield and the generator yield. It includes mismatch losses, temperature effect and non-dispatchable yield. Symbol: Lc.
Module mismatch loss	The difference between the total maximum power of devices connected in series or parallel and the sum of each device measured separately under the same conditions. This arises because of differences in individual device I-V characteristics. Units: W or dimensionless expressed normalized.
Efficiency	The ratio of output quantity over input quantity. The quantity specified is normally the power, energy, or electric charge produced by and delivered to a component. Symbol: η is commonly used. Units: dimensionless, usually expressed as a percentage (%).
Rated efficiency	Pertaining to a device: The efficiency of a device at specified operating conditions, usually standard test conditions (STC). Pertaining to an inverter: The efficiency of an inverter when it is operating at its rated output.
State of charge	The ratio between the residual capacity and the rated capacity of a storage device. Abbreviation: SOC. Units: dimensionless, usually expressed as a percentage (%).
Partial state of charge	A state indicating that an electrical storage device has not reached a full charge. Abbreviation: PSOC. Units: dimensionless, usually expressed as a percentage (%).
Depth of discharge	A value to express the discharge of an electrical storage device. The ratio of the discharge amount to the rated capacity is generally used. Abbreviation: DOD. Units: dimensionless, usually expressed as a percentage (%).
Charging efficiency	A generic term to express ampere-hour efficiency (or less commonly, watt-hour efficiency).
Ampere-hour efficiency	The ratio of the amount of electrical charge removed during discharge conditions to the amount of electrical charge added during charge conditions in an electrical storage device.

Overload capability	Output power level beyond which permanent damage occurs to a device or system. It is expressed by the ratio of overload power to rated load power for a period of time. Units: dimensionless (usually expressed as a percentage, %), and minutes.
No load loss	Input power of the converter when its load is disconnected and output voltage is present.
Standby loss	The power drawn by a power conditioner when it is in standby mode. Units: W. Pertaining to stand- alone power conditioners: The DC. input power. Pertaining to grid-connected power conditioners: The power drawn from the utility grid.
Environmental parameters	
Ambient temperature	The temperature of the air surrounding a PV generator as measured in a vented enclosure and shielded from solar. Symbol: Tamb. Unit: °C.
Angle of incidence	The angle between the direct irradiant beam and the normal to the active surface.
Azimuth angle	The projected angle between a straight line from the apparent position of the sun to the point of observation and a horizontal line normal to the equator. This is measured from due north in the southern hemisphere and from due south in the northern hemisphere. Negative azimuth values indicate an eastern orientation and positive values a western orientation. Symbol: α.
Solar elevation angle	The angle between the direct solar beam and the horizontal plane. Symbol: θ.
Tilt angle	The angle between the horizontal plane and the plane of the module surface.
Irradiance	Electromagnetic radiated power incident upon a surface, most commonly from the sun or a solar simulator. Symbol: G. Unit: W·m-2.
Global irradiance	Irradiance on a horizontal surface. This equals horizontal direct irradiance plus horizontal diffuse irradiance.
In-plane irradiance	Total irradiance on the plane of a device. Symbol: GI.
Solar energy	Common term meaning irradiation.
Irradiation	Irradiance integrated over a specified time interval. Symbol: H. Unit: J·m-2.]
Testing and certification	
Inspection	Evaluation for conformity by measuring, observing, testing, or gauging the relevant characteristics as required by the technical specifications.
Tests	Technical operations to establish of one or more characteristics of a given product or service according to a specified procedure.
Acceptance testing	Site-specific testing to assure acceptable performance as required by the technical specifications.
Verification	Confirmation by examination and recording of physical evidence that specified requirements have been met.
Verification testing	Site-specific, periodic testing to assure continued acceptable performance.
Certificate of conformity	A label, nameplate, or document of specified form and content, directly associated with a product or service on delivery to the purchaser, attesting that the product or service is in conformity with the requirements of the certification program (e.g., with the referenced standards and specifications).
Miscellaneous	
Electromagnetic interference	The condition where electromagnetic energy interferes with the proper operation of equipment. Abbreviation: EMI.
Fuel Reduction Mode	Mode of operation when the PV plant works in parallel to the diesel genset with the objective of reducing the fuel consumption
Total harmonic distortion	The ratio of effective signal of total harmonic to effective signal of basic frequency. Units: dimensionless, usually expressed as a percentage (%).
Safe extra low voltage (SELV)	An extra-low voltage system which is electrically separated from earth and from other systems in such a way that a single fault cannot give rise to the risk of electric shock.
Extra-low voltage (ELV)	Voltage not exceeding not exceeding 50 V AC. and 120 V ripple free DC (a ripple content not exceeding 10% r.m.s). Some national standards consider 75 V DC as a maximum. In consideration of ELV status, VOC of the PV generator must be used
Low voltage.(LV)	Voltage exceeding extra-low voltage, but not exceeding 1 000 V AC. or 1 500 V DC.
High voltage (HV)	Voltage exceeding low voltage.
Double insulation	Insulation comprising both basic insulation and supplementary insulation.
Earthing	A protection against electric shocks.
ATS	Automatic transfer switch
MDB	Main Distribution Board
C/O	Change Over Switch
UG	Under Ground
PCC	Point of Common Coupling

3. 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 will be responsible of providing all Engineering, Procurement and Construction works for the optimal design and operation of the plant, including but not limited to:

- Site preparation (clearing, pruning, excavation, etc);
- All planning and permitting works required for the realization of the project;
- 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, commercial Solar PV hybrid controllers, Electric panels, etc.
- 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 small UPS system for control equipment;
- The supply and installation of equipotential bonding devices and grounding system of all metal parts of plant;
- Trees trimming if required;
- All concrete bases, foundation, and civil works necessary for the support of the system
- 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 project staff 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 he must 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, however the Beneficiary building s would provide electricity subject to rational utilization of the same by 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 Building s, 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 outdoor 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 in accordance with Appendices A and B.
- Supply and deliver spare parts as indicated in the Bill of Quantities.
- Provide the Project Sign Boards for each site as might be requested by the Employer, as well as the visibility requirements regarding labelling of equipment (Details and specifications of such labelling shall be provided by the Employer on due time during the Contract execution).
- Supply and installation of battery banks with hybrid inverter/charger system to provide around 9 hours autonomy.
- All studies, all supplies, and all work necessary to complete the works, according to the applicable laws, international standards, and best industry practice, will be provided by the Contractor.

4. SITES DETAILS

4.1. Location:

The Project is located in Batroun.

4.2. Environmental and Climatic Conditions

All equipment shall be fully operational in the following conditions:

- Relative humidity up to 95%
- Ambient temperature from 2ºC to 45ºC
- Urban environment with moderate presence of dust, insects, etc.
- Maximum wind speeds of 120km/h

The monthly irradiance averages included in the tables below, shall be utilized in energy yield calculations.

4.3. Earthing System

An earthing system is already existing in the facility, and earthing connections are available at the roof and other areas in the building. 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.

5. GENERAL REQUIREMENTS

The works under this Project 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.

6. 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.

6.1. PV Modules

- Solar PV panels suitable for the project purposes and local conditions;
- The module rated power should be at least 580Wp 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 21 % 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
  - 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; and
- 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;
- 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
  - 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 25years.
- 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.

6.2. Batteries

- Lithium iron phosphate battery banks to be provided. Cells to provide high safety and efficiency.
- Batteries should be supplied with their respective battery management system (BMS). Batteries should be installed in enclosed rack system in NEMA I case rating or higher in a dedicated location according to the manufacturer's recommendations. BMS protects the cell in all angels such as abnormal temperature, current, voltage, SoC, SoH
- All battery cables must be labelled and installed in a decent manner with the necessary routing protection to inverters or chargers.
- Batteries to have more than 6000 cycles with 95% DoD
- The contractor to choose the batteries and the invertor to be compatible.
- The battery block shall have a 48V nominal operating voltage.
- The battery shall have at least the rated capacity specified in the technical specifications at the C20 discharge rate.
- Working Temperature: 0-50 deg C

- Authentication Level VDE/IEC62619/CE/UN38.3
- Modular design with the ability to add/reduce the storage capacity easily.
- The selected supplier must have been operational on the market for at least five years
- Minimum warranty of 5 years

6.3. 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 Jacket should also be electron beam cross-linked XLPE, flame retardant, UV resistant. 6mm2 cables shall 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) overbraid 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 1000kg/100mm
    - Inherent low fire hazard
    - Excellent Corrosion resistance
    - Oil resistant
    - UV resistant
    - Provides EMC screening
    - 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 25 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 level 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 (If applicable): 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.
- For underground control cables in trenches (If applicable): 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 same or better conditions.

6.4. 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.
- Separate cable trays or conduits shall be used for LV and control / signal cables.

6.5. 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)
- 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 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.
- 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.

Here is a table for the **Copper Busbar** selection of each AC panel:

BUS BAR - COPPER

Constructional details & Current carrying capacity at 35°C Amp. Temperature

SIZE in MM			AREA in Sq MM	Weight in Kg / Mtr	Current carrying capacity in Amps							
					AC (No of Bus)				DC (No of Bus)			
					I	II	III	II II	I	II	III	II II
12	X	2	24	0.209	110	200			115	205		
15	X	2	30	0.262	140	200			145	245		
15	X	3	45	0.396	170	300			175	305		
20	X	2	40	0.351	185	315			190	325		
20	X	3	60	0.529	220	380			225	390		
20	X	5	100	0.882	295	500			300	510		
25	X	3	75	0.663	270	460			275	470		
25	X	5	125	1.11	350	600			355	610		
30	X	3	90	0.796	315	540			320	560		
30	X	5	150	1.33	400	700			410	720		
40	X	3	120	1.06	420	710			430	740		
40	X	5	200	1.77	520	900			530	930		
40	X	10	400	3.55	760	1350	1850	2500	770	1400	2000	
50	X	5	250	2.22	630	1100	1650	2100	650	1150	1750	
50	X	10	500	4.44	920	1600	2250	3000	960	1700	2500	
60	X	5	300	2.66	760	1250	1760	2400	780	1300	1900	2500
60	X	10	600	5.33	1060	1900	2600	3500	1100	2000	2800	3600
80	X	5	400	3.55	970	1700	2300	3000	1000	1800	2500	3200
80	X	10	800	7.11	1380	2300	3100	4200	1450	2600	3700	4800
100	X	5	500	4.44	1200	2050	2850	3500	1250	2250	3150	4050
100	X	10	1000	8.89	1700	2800	3650	5000	1800	3200	4500	5800
120	X	10	1200	10.7	2000	3100	4100	5700	2150	3700	5200	6700
160	X	10	1600	14.2	2500	3900	5300	7300	2800	4800	6900	9000
200	X	10	2000	17.8	3000	4750	6350	8800	3400	6000	8500	10000

…

6.6. 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
- The PV system earthing will be connected to the existing building's earthing after performing all the required tests.

6.7. 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
- Minimum warranty of 2 years

6.8. 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 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
- Operation & Maintenance manual
- 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.
- Operation and Maintenance manuals for the Beneficiary's user and maintenance staff in English and Arabic.

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 six days. 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- <u>O&M Plan</u>

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 PR of Plant.

- **Annual reports** shall be prepared summarising all performance data, solar irradiation data, outages and spares data and logbooks.
- **Status reports** after any incident on Site and/ or Plant tripping shall be also prepared.

7. STANDARDS OF PERFORMANCE

7.1. 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.
- IEC International Electrotechnical Commission.

7.2. Site Safety and Prevention of Sexual Exploitation and Abuse (PSEA)

The Contractor shall be responsible for implementing strict safety measures on site in view of the type of works being implemented and shall abide by the instructions of, guidelines and procedures to be put in place by the Employer's HSSE Officer and Project Engineer.

The Contractor shall provide and erect protection items required by site conditions and as requested by the Engineer to protect persons, onsite and offsite property, as required and as supplementary to such items that have been left in place; ascertain legal and other requirements.

The Site should always be equipped with safety kit including gloves, masks, hand gel, and thermometers, in addition to work signs, warning tapes, safety pollards or protection objects to prevent any kind of accidents. The Contractor shall also hold regular training and awareness sessions for all the staff and labour regarding any necessary health measures as recommended by the Employer or the Ministry of Public health or any other pertinent entity.

The Contractor shall maintain protection in place until work is complete and danger of damage has

ceased; at such time as approved by the Engineer, remove protections.

The Contractor shall print and fix copies of the safety and safeguarding guidelines posters (In English and Arabic) on all different work areas within the site as per the pertinent HSSE guidelines and requirements. The posters' designs will be provided during the kick-off meeting.

The Contractor shall take all appropriate measures to prevent sexual harassment, exploitation or abuse of anyone by the Contractor's Personnel as stipulated in the Conditions of Contract.

The Contractor shall print and fix copies of the PSEA guidelines posters (In English and Arabic) on all different work areas within the site as per the pertinent guidelines and requirements. The posters' designs will be provided by UNIDO during the kick-off meeting.

7.3. First aid Facilities

The Contractor shall provide and maintain adequate first aid facilities on the site in accordance with the public health authorities in the Republic of Lebanon and the Lebanese Labour Code. If any accident occurs, the Contractor shall immediately notify the Employer and Engineer in writing in accordance with the pertinent HSSE guidelines and requirements.

7.4. 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.

7.5. 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.

7.6. Scheduling Requirements

The Contractor shall submit to the consultant/Engineer a work plan (schedule of works) for the project within 14 calendar days of signature of the contract. Any necessary re-submittal, subsequent planning update or adjustment should be provided within 5 calendar days from request. Failure to abide by this requirement could result in suspending any due payment under the Contract. The work plan shall be in a form and format suitable to the Engineer, and the Contractor shall be responsible for coordinating any special work plan requirements with the Engineer. As a minimum, the Programme shall be resource loaded and shall include detailed sections for submittals, procurement & delivery as well as site execution works and snagging.

The Contractor must submit a detailed breakdown planning showing item by item the duration, labours and equipment to be used.

The Contractor shall also submit a weekly schedule of the planned works mentioning the work that will be done in the following week. The Contractor shall also submit a report of the work accomplished during the preceding week.

All scheduling and planning shall be prepared through either Primavera or MS Projects.

7.7. Environmental Standards

The Contractor shall implement an environmental management plan whereby all site activities will be performed in an environmentally sound manner such as for instance considering impacts on the natural environment, water, dust and emission suppression and the proper handling and disposal of all wastes resulting from the activities undertaken under the Contract.

7.8. COVID- 19 Prevention Requirements

The Contractor must protect the health and well-being of workers in line with national measures of the Ministry of Public Health, the Ministry of Labour, and Ministry of Public Works and Transport (including the Order of Engineers and Architects). Should new national guidelines be issued, the Contractor should also take those into account. The Contractor should implement rigorous preventive measures at the workplace and site against the spread of the virus. These additional Occupational Safety and Health (OSH) measures include maintaining a minimum distance between workers at all times, the provision of protective equipment and the implementation of hygiene procedures.

These measures should be supported by awareness campaigns and information dissemination on a regular basis to the workers based on the recommendations of the Ministry of Public Health directives. The Contractor will be fully responsible to respect and implement the required guidelines and update them regularly as per the national guidelines with no additional cost or time to the Employer. The site equipment shall include as a minimum the below items on daily basis:

- Adequate hand sanitizers
- Site or medical rubber gloves
- Medical masks or face shields
- Infrared thermometers
- Soap & soap dispensers,
- Paper towels dispensers
- Disinfectants
- Site Lavatories and toilets with availability of clean water for use by all personnel/visitors
- Sign boards raising health and safety awareness on COVID 19 with a guideline including a clear contact number in case of emergency

The Contractor should provide a method statement clarifying the measures that will be applied on site in that respect. During the implementation phase of the project, the Employer and the Engineer will have the authority, at no extra cost to the Employer, to amend and add any item/step to the approved method statement, if deemed necessary for the protection of any person present on the site premises, such as but not limited to labors, the Employer's staff, Engineer's staff, the Contractor's employees, Beneficiary, third party, subcontractors.

7.9. Social Safeguards

The Contractor is required to undertake the following social safeguards provisions for workers to ensure an appropriate application of the standards that are set forth by the laws and regulations:

- Minimum age for admission to work is 18 (Note: Although the Lebanese Labour Law allows in certain cases the employability of children under the age of 18, however, and for the purpose of this project, no children under the age of 18 are allowed to be employed for reasons related to the nature of the infrastructure work that might risk the health and safety of children.)
- Gender equality and equal employability opportunities for women. The Contractor is encouraged to have female participation, especially for skilled and management positions. (Note: The Lebanese Labour Law forbids the employers to discrimination based on gender

between female and male workers in terms of type of work, salary or wage, employment, promotion, progress, professional rehabilitation and training, or dress code. A particular attention to the occupational safety and health of women in the workplace restricts the employment of women in 19 types dangerous profession as indicated by the Labour law[1].)

- Including people with disabilities in the project. The Contractor is encouraged to employ people with disabilities according to Article 74 of law number 220 /2000 on Disabled people rights, decree number 1834 on 3 December 1999[2].
- Task based wages. The Contractor should ensure that all workers, independent of their sex, ethnicity or mental or physical condition, receive the same salary for the same type of work done. The task-based payment method also facilitates the implementation of same salary for work that is of equal value.
- Induction on safety and health procedures to workers. The Contractor is required to provide safety induction training or briefing to all personnel upon starting on sites on safety, protection and health related themes. The Health and Safety Officer shall be responsible for this provision.
- First Aid kit present on site. Comprehensive and well stocked First Aid Kits shall be present on sites at all times, conveniently located and clearly identifiable, to ensure proper treatment to workers who get injured during the implementation of the work. Female hygiene products are recommended to be included in the Kit.
- Safety gear provided to workers. The Contractor shall provide personal protective equipment to workers, according to the work being implemented, including but are not limited to hard hats, safety glasses, gloves, safety shoes, hearing protections, or other means provided against cuts, corrosive liquids, and chemicals. The Contractor shall make sure that holes in the floor, sidewalk, or other walking surface are repaired properly, covered, or otherwise made safe.
- Access to drinking water at the workplace. The purpose of providing water is to prevent heat stress, heat stroke, hypothermia, hyperthermia and the medical condition of dehydration. These are all threats to workplace safety, especially in settings where employees may be working at very high or low temperatures, or outside. The provision of this social safeguard will be followed-up by the Health and Safety Officer.
- Provision of toilet and washing facilities at the workplace. The Contractor shall coordinate with the municipality to ensure enough toilets and washbasins for those expected to use them; where possible, separate facilities for men and women to prevent harassment; such facilities should have lockable doors and always be clean

[1] The positions restricted to employ women are as follows: 1) Underground work in mines, quarries, and all stone extraction work; 2) Oven work for the melting, refining and firing of mineral products; 3) Silvering mirrors by the quicksilver process; 4) Production and handling of explosives; 5) Glass melting and firing; 6) Oxyacetylene welding; 7) Production of alcohol and all other alcoholic drinks; 8) Duco painting; 9) Handling, treatment or reduction of ashes containing lead, and de-silvering lead; 10) Production of welding material or alloys with more than ten present lead content; 11) Production of litharge, massicot, minium, white lead, mico-orange or lead sulphate, chromate or silicate, 12) Mixing and pasting operations in the production or repair work of electricity accumulators; 13) Cleaning workshops where the operations listed under No.9, 10, 11 and 12 are carried out; 14) Operating driving engines; 15) Repairing or cleaning driving engines on the run; 16) Asphalt production; 17) Tannery work; 18) Work in the warehouse of fertilizers extracted from the excrement, manure, bone and blood; and 19) Cutting up animal carcasses.

[2] The type of work and equipment, machines and devices used by the worker should be appropriate to the disability he/she holds. Below are some examples of different type of physical disabilities and the work that can be done by the respective worker according to the type of Impairment

Type of Physical disabilities
Type of work
Arm amputation
Rock shattering, gravel sieving, supervising work teams, controlling traffic.
Leg amputation
Rock shattering, gravel sieving, supervising work teams, controlling traffic, maintaining tools.
Hearing impairment or deafness
All work except for traffic control. Supervisors should inform other workers about their impairment.
Visual impairment
Many tasks. Recommend avoiding work that risks eye damage e.g. Rock shattering
Mute or communication impairment
All work. Supervisors should inform other workers about their impairment.
Intellectual disability
Many tasks that are simple to demonstrate and perform

- Provision of safety transportation. The Contractor shall ensure that safety transportation is provided to the workers from and to the work sites.

7.10. Working Hours

The Contractor shall not perform any work outside agreed site working hours unless authority to do so has been obtained in writing from the Employer or its Representative.

The Contractor shall take care to prevent disruption to existing operations in the facility and surrounding establishments.

7.11. 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 Hybrid Systems at the building Beneficiary in accordance with the pertinent regulations, especially those issued by the Ministry of Energy and Water and the Ministry of Interior Affairs. In this regard, the Contractor shall be responsible to obtain the pertinent documents from the building Beneficiary, 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.

7.12. 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.

7.13. 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.
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.

7.14. 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.

7.15. 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	5

Lithium Battery	5
Weather station (Optional) and data loggers	2
Steel Structure	10
UPS	2

7.16. 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.
    - IEC 61215 standards for durability and performance for standard monocrystalline and polycrystalline PV module

- 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 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 Control Gear 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.
- Underwriters Laboratories (UL)

Scope of Work and Technical Specifications

Development of Technical Specification, Supervision of Installation and Commissioning of Solar PV System in Lebanon Orthodox Clinic Project

1. General

1.1. The Project

The objective of required services is to procure consulting services for the development of technical specification, supervision of installation and commissioning of a hybrid solar Photo Voltaic (PV) system with energy storage using lithium batteries for the Orthodox Clinic in Akkar. A 30KW Solar PV system shall be installed for this project. Implementation or execution of EE measures is not part of the current consulting assignment.

2. GLOSSARY OF TERMS

Solar photovoltaic components	
Crystalline silicon	A general category of silicon materials exhibiting a crystalline structure. Symbol: c-Si. (also single crystalline sc-Si and multi-crystalline mc-Si).
Photovoltaic module or panel	The smallest complete environmentally protected assembly of interconnected cells. Colloquially referred to as a "solar module".
Photovoltaic cell	The basic photovoltaic device. Colloquially referred to as a "solar cell".
Reference cell	A specially calibrated cell that is used to measure irradiance.
Rated capacity STC	The PV module power delivered at the maximum power point at standard test conditions (STC).
Hot spot	The intense, localized heating of a spot on a cell in a module where a breakdown of the junction on that cell has occurred due to an excessively high reverse voltage bias or by some damage. This creates a small, localized shunt path through which a large portion of the module current flows.
Bypass diode (on a module level)	A diode connected across one or more cells in the forward current direction to allow the module current to bypass cells to prevent hot spot or hot cell damage resulting from the reverse voltage biasing from the other cells in that module.
DC converter	An electronic component that changes the generator output voltage into a useable DC voltage.
Maximum power point tracking	A control strategy for DC converters and PV inverters whereby the PV generator operation is always near the point of current-voltage characteristic where the product of current and voltage yields the maximum electrical power under the operating conditions. Abbreviation: MPPT.
Inverter	A system component that converts DC electricity into AC electricity. One of the family of components that is included in "power conditioner".
String inverter	An inverter designed to operate with only one string of PV modules. The output in AC can be connected in parallel with other similar inverters.
Multi-string inverter	An inverter designed to operate with more than one string of PV modules. The output in AC can be connected in parallel with other similar inverters.
Grid-connected inverter	An inverter that is able to operate in grid-parallel with a utility supply authority.
Grid-dependent inverter	An inverter that can only operate in grid-parallel with an AC electric grid. Also known as a grid-tied inverter.

Dual mode inverter	A type of inverter that is able to operate in both autonomous and grid-parallel modes according to the availability of the utility supply authority. This type of inverter initiates autonomous operation.
Autonomous inverter	An inverter that supplies a load not connected to an electric utility. Also known as a "battery-powered inverter" or "stand-alone inverter"
Voltage control inverter	An inverter with an output voltage that is a specified sine wave produced by pulse-width modulated (PWM) control etc.
Current control inverter	An inverter with an output current that is a specified sine wave produced by pulse-width modulated (PWM) control etc.
Junction box	An enclosure in which circuits are electrically connected and where protection devices can be located.
Generator junction box	A junction box in which the photovoltaic module circuits are electrically connected and where string protection devices are located.
Utility interface disconnect switch	A switch at the interface between the photovoltaic system and the utility grid.
Storage	Accumulation of electricity in a non-electric form and which can be reconverted through the system to electricity.
Lithium ion battery	A lithium-ion (Li-ion) battery is an advanced battery technology that uses lithium ions as a key component of its electrochemistry
BESS	A Battery Emergency Storage System (BESS) is any electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its safe operating area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it
Solar photovoltaic power plants	
Distributed generation plant	The facility and equipment comprising an electricity generation plant that is interconnected to and operates in parallel with a distribution system.
Distribution system	An electrical facility and its components including poles, transformers, disconnects, isolators and wires that are operated by an electric utility to distribute electrical energy from substations to customers. Also referred to as electric grid.
Electric utility	The organization responsible for the installation, operation and maintenance of all or some portions of major electric generation, transmission, and distribution systems.
Energy and Management System	Component with the objective of ensuring the proper management of the power plant (EMS)
Genset	A colloquial term meaning “engine-generator set” consisting of an engine coupled to a rotating electric generator.
Individual electrification plant	A small electric generating system that supplies electricity to one consumption point usually from a single energy source.
Interconnection	the result of the process of electrically connecting a distributed generation plant to a distribution system in order to enable the two systems to operate in parallel with each other.
Autonomous operation	The operating mode in which loads are electrified solely by the PV plant and not in parallel with the utility. Also known as stand-alone or off-grid.
Grid-connected operation	The operating mode in which a PV plant is operating in parallel with an electric grid. Site loads will be electrified by either or both the utility or the plant. Electricity will be able to flow into the grid if the utility permits back feed operation. In the case of the present Project, grid connected operation will have a third possible source: on-site diesel generators
Photovoltaic generator	A mechanically integrated assembly of modules or panels and its support structure that forms an electricity producing sub-system. This does not include energy storage devices or power conditioners. Also known as array.
Photovoltaic string	A circuit of series-connected modules.
Photovoltaic plant	A photovoltaic generator and other components that generate and supply electricity suitable for the intended application. The component list and system configuration varies according to the application, and could also include: power conditioning, storage, system monitoring and control and utility grid interface. Also known as a photovoltaic system. Some such plants are grid-connected and large and others can also be small (micro plants), off-grid or even diesel grid connected. The following terms describe common system configurations.
Hybrid photovoltaic plant	In this Project; it is referred to a plant with: Grid, RE (this case PV) plant and Diesel generator
Multi-source photovoltaic plant	A power plant with photovoltaic generation operating in parallel with other electricity generators. In this Project it could refer to “Dual mode” “Off-grid” and "hybrid" system as all three have more than one source. Kindly refer to the function configuration section for more details
Site	The geographical location of a plant.
Sub-system	An assembly of components. The following terms describe common subsystems.
Monitor and control sub- system	The logic and control component(s) that supervise(s) the overall operation of the plant by controlling the interaction between all sub-systems.
Safety disconnect sub- system	The component(s) that monitor(s) utility grid conditions and open(s) a safety disconnect for out-of- bound conditions.

Data logging and evaluation sub-system	The measurement and logic component(s) that register and process all relevant operational parameters and data of the plant to establish the daily, monthly and annual final yields, losses and performance of the subsystems.
Solar photovoltaic plant performance parameters	
Standard test conditions (STC)	Reference values of in-plane irradiance (GI,ref = 1 000 W.m-2), air temperature (25°C), and air mass (AM = 1,5) to be used during the testing of any photovoltaic device. Abbreviation: STC.
Voltage of a photovoltaic generator	the PV generator voltage is considered to be equal to open circuit voltage under worst case conditions.
Open circuit voltage of a photovoltaic generator	The open circuit voltage at STC of a PV generator, and is equal to: VOC pvg = VOC MOD X M , where M is the number of series-connected PV modules in any PV string of the generator.
Short circuit current of a photovoltaic generator	the short circuit current at STC of a PV generator, and is equal to: ISC pvg = ISC STC MOD X Sg, where Sg is the total number of parallel-connected strings in the PV generator.
Load	An electrical component that converts electricity into a form of useful energy and only operates when voltage is applied.
Performance ratio	The overall effect of losses on an array's rated output due to array temperature, incomplete utilization of the irradiation, and system component inefficiencies or failures. Commonly found by the quotient of the final system yield over the reference yield. Symbol: PR
Yield	The equivalent amount of time that a plant would need to operate at its rated capacity at STC in order to generate the same amount of energy that it actually did generate. A yield indicates actual device or system operation normalized to its rated capacity.
Reference yield	The amount of time that the irradiance would need to be at reference irradiance levels to contribute the same incident irradiation as actually occurred. It is calculated from the quotient of the total irradiation over the reference irradiance. Symbol: Yr. NOTE: If GI,ref = 1 kW·m−2 then the irradiation as expressed in kWh·m-2 over any period of time is numerically equal to energy as expressed in kWh·kW-1 over that same period. Thus, Yr would be, in effect, "peak sun-hours" over that same period.
Final plant yield	The net energy that was supplied during a given period of time by the photovoltaic generator normalized to its rated PV capacity. Symbol: Yf.
Final annual yield	The total photovoltaic energy delivered to the load during one year per unit of installed PV capacity.
Losses	The electrical power or energy that does not result in the service that is intended for the electricity.
Normalized losses	The amount of time that a device or system would need to operate at its rated capacity in order to provide for system energy losses. These are commonly calculated from a difference in yields.
Plant rated power	Pertaining to PV autonomous plants: The power generated when connected to a rated load. Pertaining to PV grid-connected plants: The power that can be injected under standard operating conditions.
Generator rated capacity	The rated power generation of a photovoltaic generator, usually at STC.
Generator yield	The photovoltaic energy generated per unit of installed generator capacity. Also referred to as array yield. Symbol: Ya.
PV generator capture losses	The normalized losses due to photovoltaic generator operation, found by the difference between the reference yield and the generator yield. It includes mismatch losses, temperature effect and non-dispatchable yield. Symbol: Lc.
Module mismatch loss	The difference between the total maximum power of devices connected in series or parallel and the sum of each device measured separately under the same conditions. This arises because of differences in individual device I-V characteristics. Units: W or dimensionless expressed normalized.
Efficiency	The ratio of output quantity over input quantity. The quantity specified is normally the power, energy, or electric charge produced by and delivered to a component. Symbol: η is commonly used. Units: dimensionless, usually expressed as a percentage (%).
Rated efficiency	Pertaining to a device: The efficiency of a device at specified operating conditions, usually standard test conditions (STC). Pertaining to an inverter: The efficiency of an inverter when it is operating at its rated output.
State of charge	The ratio between the residual capacity and the rated capacity of a storage device. Abbreviation: SOC. Units: dimensionless, usually expressed as a percentage (%).
Partial state of charge	A state indicating that an electrical storage device has not reached a full charge. Abbreviation: PSOC. Units: dimensionless, usually expressed as a percentage (%).
Depth of discharge	A value to express the discharge of an electrical storage device. The ratio of the discharge amount to the rated capacity is generally used. Abbreviation: DOD. Units: dimensionless, usually expressed as a percentage (%).
Charging efficiency	A generic term to express ampere-hour efficiency (or less commonly, watt-hour efficiency).
Ampere-hour efficiency	The ratio of the amount of electrical charge removed during discharge conditions to the amount of electrical charge added during charge conditions in an electrical storage device.

Overload capability	Output power level beyond which permanent damage occurs to a device or system. It is expressed by the ratio of overload power to rated load power for a period of time. Units: dimensionless (usually expressed as a percentage, %), and minutes.
No load loss	Input power of the converter when its load is disconnected and output voltage is present.
Standby loss	The power drawn by a power conditioner when it is in standby mode. Units: W. Pertaining to stand- alone power conditioners: The DC. input power. Pertaining to grid-connected power conditioners: The power drawn from the utility grid.
Environmental parameters	
Ambient temperature	The temperature of the air surrounding a PV generator as measured in a vented enclosure and shielded from solar. Symbol: Tamb. Unit: °C.
Angle of incidence	The angle between the direct irradiant beam and the normal to the active surface.
Azimuth angle	The projected angle between a straight line from the apparent position of the sun to the point of observation and a horizontal line normal to the equator. This is measured from due north in the southern hemisphere and from due south in the northern hemisphere. Negative azimuth values indicate an eastern orientation and positive values a western orientation. Symbol: α.
Solar elevation angle	The angle between the direct solar beam and the horizontal plane. Symbol: θ.
Tilt angle	The angle between the horizontal plane and the plane of the module surface.
Irradiance	Electromagnetic radiated power incident upon a surface, most commonly from the sun or a solar simulator. Symbol: G. Unit: W·m-2.
Global irradiance	Irradiance on a horizontal surface. This equals horizontal direct irradiance plus horizontal diffuse irradiance.
In-plane irradiance	Total irradiance on the plane of a device. Symbol: GI.
Solar energy	Common term meaning irradiation.
Irradiation	Irradiance integrated over a specified time interval. Symbol: H. Unit: J·m-2.]
Testing and certification	
Inspection	Evaluation for conformity by measuring, observing, testing, or gauging the relevant characteristics as required by the technical specifications.
Tests	Technical operations to establish of one or more characteristics of a given product or service according to a specified procedure.
Acceptance testing	Site-specific testing to assure acceptable performance as required by the technical specifications.
Verification	Confirmation by examination and recording of physical evidence that specified requirements have been met.
Verification testing	Site-specific, periodic testing to assure continued acceptable performance.
Certificate of conformity	A label, nameplate, or document of specified form and content, directly associated with a product or service on delivery to the purchaser, attesting that the product or service is in conformity with the requirements of the certification program (e.g., with the referenced standards and specifications).
Miscellaneous	
Electromagnetic interference	The condition where electromagnetic energy interferes with the proper operation of equipment. Abbreviation: EMI.
Fuel Reduction Mode	Mode of operation when the PV plant works in parallel to the diesel genset with the objective of reducing the fuel consumption
Total harmonic distortion	The ratio of effective signal of total harmonic to effective signal of basic frequency. Units: dimensionless, usually expressed as a percentage (%).
Safe extra low voltage (SELV)	An extra-low voltage system which is electrically separated from earth and from other systems in such a way that a single fault cannot give rise to the risk of electric shock.
Extra-low voltage (ELV)	Voltage not exceeding not exceeding 50 V AC. and 120 V ripple free DC (a ripple content not exceeding 10% r.m.s). Some national standards consider 75 V DC as a maximum. In consideration of ELV status, VOC of the PV generator must be used
Low voltage.(LV)	Voltage exceeding extra-low voltage, but not exceeding 1 000 V AC. or 1 500 V DC.
High voltage (HV)	Voltage exceeding low voltage.
Double insulation	Insulation comprising both basic insulation and supplementary insulation.
Earthing	A protection against electric shocks.
ATS	Automatic transfer switch
MDB	Main Distribution Board
C/O	Change Over Switch
UG	Under Ground
PCC	Point of Common Coupling

3. 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 will be responsible of providing all Engineering, Procurement and Construction works for the optimal design and operation of the plant, including but not limited to:

- Site preparation (clearing, pruning, excavation, etc);
- All planning and permitting works required for the realization of the project;
- 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, commercial Solar PV hybrid controllers, Electric panels, etc.
- 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 small UPS system for control equipment;
- The supply and installation of equipotential bonding devices and grounding system of all metal parts of plant;
- Trees trimming if required;
- All concrete bases, foundation, and civil works necessary for the support of the system
- 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 project staff 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 he must 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, however the Beneficiary building s would provide electricity subject to rational utilization of the same by 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 Building s, 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 outdoor 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 in accordance with Appendices A and B.
- Supply and deliver spare parts as indicated in the Bill of Quantities.
- Provide the Project Sign Boards for each site as might be requested by the Employer, as well as the visibility requirements regarding labelling of equipment (Details and specifications of such labelling shall be provided by the Employer on due time during the Contract execution).
- Supply and installation of battery banks with hybrid inverter/charger system to provide around 9 hours autonomy.
- All studies, all supplies, and all work necessary to complete the works, according to the applicable laws, international standards, and best industry practice, will be provided by the Contractor.

4. SITES DETAILS

4.1. Location:

The Project is located at Sheikh Taba Akkar.

4.2. Environmental and Climatic Conditions

All equipment shall be fully operational in the following conditions:

- Relative humidity up to 95%
- Ambient temperature from 2ºC to 45ºC
- Urban environment with moderate presence of dust, insects, etc.
- Maximum wind speeds of 120km/h

The monthly irradiance averages included in the tables below, shall be utilized in energy yield calculations.

4.3. Earthing System

An earthing system is already existing in the facility, and earthing connections are available at the roof and other areas in the building. 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.

5. GENERAL REQUIREMENTS

The works under this Project 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.

6. 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.

6.1. PV Modules

- Solar PV panels suitable for the project purposes and local conditions;
- The module rated power should be at least 580Wp 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 21 % 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
  - 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; and
- 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;
- 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
  - 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 25years.
- 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.

6.2. Inverters

Hybrid Inverters

- Hybrid inverters work with batteries to store excess power as well
- Hybrid inverter shall be provided as shown on the drawings and schedules and in the bills of quantities with at least two MPPTs per inverter;
- Should be capable of charging battery banks and supply AC current from battery storage rack.
- 400V, three-phase, 50 HZ output
- Minimum of 2 MPPT
- MPP tracking channel wider or equal to 430 VDC-720 or larger window VDC.
- Battery voltage range 40-60V
- Dynamic compensation of reactive power, inverter automatic reconnection conditions, linear output power control from a third device (read and write capabilities), utility-interactive photovoltaic inverter system.

- Ground connection of the inverter(s) to the equipotential bonding conductor and to the protective conductor on the AC Side;
- Insulation testing feature on DC side;
- The minimum 'European Efficiency' of the inverter shall be a minimum of 97.9%;
- Complete installation following recommendations by the manufacturer (minimum spacing, fixation, sun shed, etc.);
- Ground connection of the inverter to the equipotential bonding conductor and to the protective conductor of the AC side;
- DC fuses on at both the positive (+) and the negative (-) polarity on the DC side (can be done in an external DC box if not possible within the inverter);
- PV specific surge arrester type 1+2 shall be provided on the DC side;
- AC Type 1+2 surge arrestor shall be provided on the AC side;
- Setting, labelling, and commissioning of inverters;
- MODBUS or CAN (with communication bridge if required), allowing reading and writing on the inverter
- Inverters shall be suitable for the Plant climatic conditions and with proven track record for similar projects; however, the supplied inverter(s) capacity shall be at a minimum temperature of 40 degrees Celsius.
- Suitable consideration of inverter ventilation to avoid potential capacity de-rating;
- Compliance to IEC/EN 61000-6-1/2/3/4, IEC/EN 62109-1, IEC/EN 62109-2
- Minimum warranty of 5 years

6.3. Batteries

- Lithium iron phosphate battery banks to be provided. Cells to provide high safety and efficiency.
- Batteries should be supplied with their respective battery management system (BMS). Batteries should be installed in enclosed rack system in NEMA I case rating or higher in a dedicated location according to the manufacturer's recommendations. BMS protects the cell in all angels such as abnormal temperature, current, voltage, SoC, SoH
- All battery cables must be labelled and installed in a decent manner with the necessary routing protection to inverters or chargers.
- Batteries to have more than 6000 cycles with 95% DoD
- The contractor to choose the batteries and the invertor to be compatible.
- The battery block shall have a 48V nominal operating voltage.
- The battery shall have at least the rated capacity specified in the technical specifications at the C20 discharge rate.
- Working Temperature: 0-50 deg C
- Authentication Level VDE/IEC62619/CE/UN38.3
- Modular design with the ability to add/reduce the storage capacity easily.
- The selected supplier must have been operational on the market for at least five years
- Minimum warranty of 5 years

6.4. 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 Jacket should also be electron beam cross-linked XLPE, flame retardant, UV resistant. 6mm2 cables shall 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) overbraid 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 1000kg/100mm
    - Inherent low fire hazard
    - Excellent Corrosion resistance
    - Oil resistant
    - UV resistant
    - Provides EMC screening
    - 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 25 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 level 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 (If applicable): 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.
- For underground control cables in trenches (If applicable): 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 same or better conditions.

6.5. 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.
- Separate cable trays or conduits shall be used for LV and control / signal cables.

6.6. 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 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.
- 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.

Here is a table for the **Copper Busbar** selection of each AC panel:

BUS BAR - COPPER

Constructional details & Current carrying capacity at 35°C Amp. Temperature

SIZE in MM			AREA in Sq MM	Weight in Kg / Mtr	Current carrying capacity in Amps							
					AC (No of Bus)				DC (No of Bus)			
					I	II	III	II II	I	II	III	II II
12	X	2	24	0.209	110	200			115	205		
15	X	2	30	0.262	140	200			145	245		
15	X	3	45	0.396	170	300			175	305		
20	X	2	40	0.351	185	315			190	325		
20	X	3	60	0.529	220	380			225	390		
20	X	5	100	0.882	295	500			300	510		
25	X	3	75	0.663	270	460			275	470		
25	X	5	125	1.11	350	600			355	610		
30	X	3	90	0.796	315	540			320	560		
30	X	5	150	1.33	400	700			410	720		
40	X	3	120	1.06	420	710			430	740		
40	X	5	200	1.77	520	900			530	930		
40	X	10	400	3.55	760	1350	1850	2500	770	1400	2000	
50	X	5	250	2.22	630	1100	1650	2100	650	1150	1750	
50	X	10	500	4.44	920	1600	2250	3000	960	1700	2500	
60	X	5	300	2.66	760	1250	1760	2400	780	1300	1900	2500
60	X	10	600	5.33	1060	1900	2600	3500	1100	2000	2800	3600
80	X	5	400	3.55	970	1700	2300	3000	1000	1800	2500	3200
80	X	10	800	7.11	1380	2300	3100	4200	1450	2600	3700	4800
100	X	5	500	4.44	1200	2050	2850	3500	1250	2250	3150	4050
100	X	10	1000	8.89	1700	2800	3650	5000	1800	3200	4500	5800
120	X	10	1200	10.7	2000	3100	4100	5700	2150	3700	5200	6700
160	X	10	1600	14.2	2500	3900	5300	7300	2800	4800	6900	9000
200	X	10	2000	17.8	3000	4750	6350	8800	3400	6000	8500	10000

…

6.7. Monitoring & Data Acquisition

The Contractor is responsible for the supply and installation of a data acquisition unit (data logger) for efficient plant operation and control and compatibility with all measuring components. All measurements are to be logged locally, and available from a remote location through an internet connection, including the data from the weather stations (optional), the inverters, the energy meters, and the solar-diesel controller.

- Optional: Supply, installation and connection of a solar technology sensors and temperature (ambient temperature + modules reference) within a weather monitoring station complete with sensors with valid calibration certificates including as a minimum (on each station):
  - 1 x Global Horizontal Irradiance pyranometers;
  - 1 x Plane of Array Irradiance pyranometers;
  - 1 x Shielded and ventilated ambient temperature sensors;
  - 1 x module temperature sensors;
  - 1 x wind speed sensors.

- Supply, installation and connection of energy meters at the injection points. The meters should measure 4 quadrant power parameters and be compatible with the solar-diesel controller.
- Provision of data acquisition software;
- The system should be capable to operate through both GSM and LAN, the Contractor should provide all accessories needed such as sim card and modules;
- A data access for remote monitoring shall be provided to the Employer and the facility operator;
- Logs of all inverter's measurements should be recorded, including at least, per inverter
  - AC power in kW
  - Reactive power in kVAr
  - Apparent power in kVA
  - Power frequency in Hz
  - Grid AC voltage in V
  - Grid AC current in A
  - DC voltage
  - DC current
  - Daily delivered energy in kWh (i.e. the energy delivered by each inverter on each calendar day).

- A UPS system should be included to power all monitoring and controller equipment. The UPS should have a 1kWh battery storage capacity and a 1000W power rating. The UPS operating voltages should be chosen according to the offered components requirements.

6.8. Dynamic Display Panel

- 50-inch TV screen and display interface for indoor use, exact location to be approved by the Employer and the building management.
- Should display at least the below data:
  - Solar penetration in %,
  - Demand load in KW
  - Genset contribution in % and in KW
  - EDL power availability
  - Running gensets indication
  - Total produced Energy (MWh),
  - Cumulative CO2 emission saved (Ton).
  - Weather data and cell temperatures
  - Alarm display page
- Graphic design considering the illustrations and texts to be approved by the Employer's Engineer.

- The Contractor will be responsible for the supply and installation of a communication device between the Plant remote monitoring system and the TV display (through LAN or other wired technology as convenient).

6.9. 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
- The PV system earthing will be connected to the existing building's earthing after performing all the required tests.

6.10. Interconnection to the Facility Grid

The interconnection to the grid shall be done as shown on the riser diagram. The main interconnection to the facility grid should be highly coordinated with the Employer and the facility, with minimum or no disturbance to the facility grid.

For any deviation from the original design regarding the different equipment location, cable lengths, or the connection point panel, the following points shall be checked and recalculated by the contractor:

The tapping point should be checked for each side to make sure that:

- The connection point panel is able to handle the solar injected capacity
- Busbar rating is able to handle the solar generation
- There will be no drawbacks on the system short circuit capability due to solar contribution
- A load flow analysis to check the system capability in terms of short circuit and voltage drop
- Minimum variation should be allowed in terms of voltage drop to be less than 2 % at the point of common coupling after PV connection.

Total system ohmic loss should be simulated and determined, the total PV internal loss from the panels to the point of common coupling should be less than 3 %

6.11. 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

- Minimum warranty of 2 years

6.12. 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 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
- Operation & Maintenance manual
- 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.
- Operation and Maintenance manuals for the Beneficiary's user and maintenance staff in English and Arabic.

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 six days. 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 PR of Plant.
  - **Annual reports** shall be prepared summarising all performance data, solar irradiation data, outages and spares data and logbooks.
  - **Status reports** after any incident on Site and/ or Plant tripping shall be also prepared.

7. STANDARDS OF PERFORMANCE

7.1. 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.
- IEC International Electrotechnical Commission.

7.2. Site Safety and Prevention of Sexual Exploitation and Abuse (PSEA)

The Contractor shall be responsible for implementing strict safety measures on site in view of the type of works being implemented and shall abide by the instructions of, guidelines and procedures to be put in place by the Employer's HSSE Officer and Project Engineer.

The Contractor shall provide and erect protection items required by site conditions and as requested by the Engineer to protect persons, onsite and offsite property, as required and as supplementary to such items that have been left in place; ascertain legal and other requirements.

The Site should always be equipped with safety kit including gloves, masks, hand gel, and thermometers, in addition to work signs, warning tapes, safety pollards or protection objects to prevent any kind of accidents. The Contractor shall also hold regular training and awareness sessions for all the staff and labour regarding any necessary health measures as recommended by the Employer or the Ministry of Public health or any other pertinent entity.

The Contractor shall maintain protection in place until work is complete and danger of damage has ceased; at such time as approved by the Engineer, remove protections.

The Contractor shall print and fix copies of the safety and safeguarding guidelines posters (In English and Arabic) on all different work areas within the site as per the pertinent HSSE guidelines and requirements. The posters' designs will be provided during the kick-off meeting.

The Contractor shall take all appropriate measures to prevent sexual harassment, exploitation or abuse of anyone by the Contractor's Personnel as stipulated in the Conditions of Contract.

The Contractor shall print and fix copies of the PSEA guidelines posters (In English and Arabic) on all different work areas within the site as per the pertinent guidelines and requirements. The posters' designs will be provided by UNIDO during the kick-off meeting.

7.3. First aid Facilities

The Contractor shall provide and maintain adequate first aid facilities on the site in accordance with the public health authorities in the Republic of Lebanon and the Lebanese Labour Code. If any accident occurs, the Contractor shall immediately notify the Employer and Engineer in writing in accordance with the pertinent HSSE guidelines and requirements.

7.4. 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.

7.5. 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.

7.6. Scheduling Requirements

The Contractor shall submit to the consultant/Engineer a work plan (schedule of works) for the project within 14 calendar days of signature of the contract. Any necessary re-submittal, subsequent planning update or adjustment should be provided within 5 calendar days from request. Failure to abide by this requirement could result in suspending any due payment under the Contract. The work plan shall be in a form and format suitable to the Engineer, and the Contractor shall be responsible for coordinating any special work plan requirements with the Engineer. As a minimum, the Programme shall be resource loaded and shall include detailed sections for submittals, procurement & delivery as well as site execution works and snagging.

The Contractor must submit a detailed breakdown planning showing item by item the duration, labours and equipment to be used.

The Contractor shall also submit a weekly schedule of the planned works mentioning the work that will be done in the following week. The Contractor shall also submit a report of the work accomplished during the preceding week.

All scheduling and planning shall be prepared through either Primavera or MS Projects.

7.7. Environmental Standards

The Contractor shall implement an environmental management plan whereby all site activities will be performed in an environmentally sound manner such as for instance considering impacts on the natural environment, water, dust and emission suppression and the proper handling and disposal of all wastes resulting from the activities undertaken under the Contract.

7.8. COVID- 19 Prevention Requirements

The Contractor must protect the health and well-being of workers in line with national measures of the Ministry of Public Health, the Ministry of Labour, and Ministry of Public Works and Transport (including the Order of Engineers and Architects). Should new national guidelines be issued, the Contractor should also take those into account. The Contractor should implement rigorous preventive measures at the workplace and site against the spread of the virus. These additional Occupational Safety and Health (OSH) measures include maintaining a minimum distance between workers at all times, the provision of protective equipment and the implementation of hygiene procedures.

These measures should be supported by awareness campaigns and information dissemination on a regular basis to the workers based on the recommendations of the Ministry of Public Health directives. The Contractor will be fully responsible to respect and implement the required guidelines and update them regularly as per the national guidelines with no additional cost or time to the Employer. The site equipment shall include as a minimum the below items on daily basis:

- Adequate hand sanitizers
- Site or medical rubber gloves
- Medical masks or face shields
- Infrared thermometers

- Soap & soap dispensers,
- Paper towels dispensers
- Disinfectants
- Site Lavatories and toilets with availability of clean water for use by all personnel/visitors
- Sign boards raising health and safety awareness on COVID 19 with a guideline including a clear contact number in case of emergency

The Contractor should provide a method statement clarifying the measures that will be applied on site in that respect. During the implementation phase of the project, the Employer and the Engineer will have the authority, at no extra cost to the Employer, to amend and add any item/step to the approved method statement, if deemed necessary for the protection of any person present on the site premises, such as but not limited to labors, the Employer's staff, Engineer's staff, the Contractor's employees, Beneficiary, third party, subcontractors.

7.9. Social Safeguards

The Contractor is required to undertake the following social safeguards provisions for workers to ensure an appropriate application of the standards that are set forth by the laws and regulations:

- Minimum age for admission to work is 18 (Note: Although the Lebanese Labour Law allows in certain cases the employability of children under the age of 18, however, and for the purpose of this project, no children under the age of 18 are allowed to be employed for reasons related to the nature of the infrastructure work that might risk the health and safety of children.)
- Gender equality and equal employability opportunities for women. The Contractor is encouraged to have female participation, especially for skilled and management positions. (Note: The Lebanese Labour Law forbids the employers to discrimination based on gender between female and male workers in terms of type of work, salary or wage, employment, promotion, progress, professional rehabilitation and training, or dress code. A particular attention to the occupational safety and health of women in the workplace restricts the employment of women in 19 types dangerous profession as indicated by the Labour law[1].)
- Including people with disabilities in the project. The Contractor is encouraged to employ people with disabilities according to Article 74 of law number 220 /2000 on Disabled people rights, decree number 1834 on 3 December 1999[2].
- Task based wages. The Contractor should ensure that all workers, independent of their sex, ethnicity or mental or physical condition, receive the same salary for the same type of

[1] The positions restricted to employ women are as follows: 1) Underground work in mines, quarries, and all stone extraction work; 2) Oven work for the melting, refining and firing of mineral products; 3) Silvering mirrors by the quicksilver process; 4) Production and handling of explosives; 5) Glass melting and firing; 6) Oxyacetylene welding; 7) Production of alcohol and all other alcoholic drinks; 8) Duco painting; 9) Handling, treatment or reduction of ashes containing lead, and de-silvering lead; 10) Production of welding material or alloys with more than ten present lead content; 11) Production of litharge, massicot, minium, white lead, mico-orange or lead sulphate, chromate or silicate, 12) Mixing and pasting operations in the production or repair work of electricity accumulators; 13) Cleaning workshops where the operations listed under No.9, 10, 11 and 12 are carried out; 14) Operating driving engines; 15) Repairing or cleaning driving engines on the run; 16) Asphalt production; 17) Tannery work; 18) Work in the warehouse of fertilizers extracted from the excrement, manure, bone and blood; and 19) Cutting up animal carcasses.

[2] The type of work and equipment, machines and devices used by the worker should be appropriate to the disability he/she holds. Below are some examples of different type of physical disabilities and the work that can be done by the respective worker according to the type of Impairment

Type of Physical disabilities	Type of work
Arm amputation	Rock shattering, gravel sieving, supervising work teams, controlling traffic.
Leg amputation	Rock shattering, gravel sieving, supervising work teams, controlling traffic, maintaining tools.
Hearing impairment or deafness	All work except for traffic control. Supervisors should inform other workers about their impairment.
Visual impairment	Many tasks. Recommend avoiding work that risks eye damage e.g. Rock shattering
Mute or communication impairment	All work. Supervisors should inform other workers about their impairment.
Intellectual disability	Many tasks that are simple to demonstrate and perform

work done. The task-based payment method also facilitates the implementation of same salary for work that is of equal value.

- Induction on safety and health procedures to workers. The Contractor is required to provide safety induction training or briefing to all personnel upon starting on sites on safety, protection and health related themes. The Health and Safety Officer shall be responsible for this provision.
- First Aid kit present on site. Comprehensive and well stocked First Aid Kits shall be present on sites at all times, conveniently located and clearly identifiable, to ensure proper treatment to workers who get injured during the implementation of the work. Female hygiene products are recommended to be included in the Kit.
- Safety gear provided to workers. The Contractor shall provide personal protective equipment to workers, according to the work being implemented, including but are not limited to hard hats, safety glasses, gloves, safety shoes, hearing protections, or other means provided against cuts, corrosive liquids, and chemicals. The Contractor shall make sure that holes in the floor, sidewalk, or other walking surface are repaired properly, covered, or otherwise made safe.
- Access to drinking water at the workplace. The purpose of providing water is to prevent heat stress, heat stroke, hypothermia, hyperthermia and the medical condition of dehydration. These are all threats to workplace safety, especially in settings where employees may be working at very high or low temperatures, or outside. The provision of this social safeguard will be followed-up by the Health and Safety Officer.
- Provision of toilet and washing facilities at the workplace. The Contractor shall coordinate with the municipality to ensure enough toilets and washbasins for those expected to use them; where possible, separate facilities for men and women to prevent harassment; such facilities should have lockable doors and always be clean
- Provision of safety transportation. The Contractor shall ensure that safety transportation is provided to the workers from and to the work sites.

7.10. Working Hours

The Contractor shall not perform any work outside agreed site working hours unless authority to do so has been obtained in writing from the Employer or its Representative.

The Contractor shall take care to prevent disruption to existing operations in the facility and surrounding establishments.

7.11. 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 Hybrid Systems at the building Beneficiary in accordance with the pertinent regulations, especially those issued by the Ministry of Energy and Water and the Ministry of Interior Affairs. In this regard, the Contractor shall be responsible to obtain the pertinent documents from the building Beneficiary, 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.

7.12. 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.

7.13. 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.
    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.

7.14. 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.

7.15. 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	5
Lithium Battery	5
Weather station (Optional) and data loggers	2
Steel Structure	10
UPS	2

7.16. 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.
    - IEC 61215 standards for durability and performance for standard monocrystalline and polycrystalline PV module

- 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 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 Control Gear 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.
    - Underwriters Laboratories (UL)

SINGLE LINE DIAGRAM GENERAL LEGEND		
Symbol	**Designation**	**Description**
		Grid-Tied Inverter, three phase
		Fuse protection
		DC Fuse disconnector
		PV-panels, 545Wp Mono-crystalline
		Surge arrestors for overcurrent protection
		Molded Case Circuit Breaker
		Motorized Molded Case Circuit Breaker
		Disconnect
		Molded Case Circuit Breaker with 300mA RCD
		Power measuring device
		Solar Inverters communication and monitoring cables (STP twisted pairs CAT6A)
		Power meters communication network bus Type of cable shall be as per the selected manufacturer recommendations

EXISTING SYSTEM OUT OF SCOPE

CC3 (NEW)

CC2 (EXISTING)

ROOF

1*8 + 1*9
545W Solar Panel

DOUBLE INSULATED DC CABLES 2X6MM2

800V 20A DC Fuse disconnectors on Positive and negative Polarities shall be provided

NEW DC PANEL

1*8 + 1*9
545W Solar Panel

DOUBLE INSULATED DC CABLES 2X6MM2

800V 20A DC Fuse disconnectors on Positive and negative Polarities shall be provided

NEW DC PANEL

2*9
545W Solar Panel

DOUBLE INSULATED DC CABLES 2X6MM2

800V 20A DC Fuse disconnectors on Positive and negative Polarities shall be provided

NEW DC PANEL

STRING 01: 9 PANELS x 545W
STRING 02: 8 PANELS x 545W
STRING 03: 9 PANELS x 545W

MPPT1 MPPT2 MPPT3

12kWac

INV 1 EXISTING

INV 2 EXISTING

INV 3

Wind sensors
Module Temp.
Ambient Temp.
WEATHER STATION
Global Horizontal Irradiation GHI
Global Tilted Irradiation GTI

CC4 (EXISTING)

CC1 (EXISTING)

CC5

SWITCH

Monitoring and Data logging

INTERNET

UPS

Solar Hybrid Controller

CC6 (EXISTING)

F1-1

F1-2

EXISTING CABLE

CU/PVC/PVC + CU/PVC
3x6+6mm2,
380VAC

COPPER Busbar: 100A, 380V, 3ϕ, 4W, 25KA

300A/5A CT'S CLASS I (3-NOS)

Meter

U and I Sensing

Surge arrester
Type 1+2
I MAX = 50 kA, I n = 25 kA
3-phase + Neutral 380VAC

Disconnect switch 380VAC 300A

300A

MAIN PV AC PANEL EXISTING

CU/PVC/PVC + CU/PVC
3x35+16mm2,
380VAC

IT IS THE CONTRACTOR RESPONSIBILITY TO VERIFY THE RATING OF EXISTING DISCONNECT TO BE 80A TO WITHSTAND THIS LOAD. IF LESS THAN 80A RATING, THE CONTRACTOR SHALL REPLACE IT TO MATCH THE NEW REQUIREMENTS.

SPECIAL ATTENTION SHALL BE MADE TO THE BUSBAR RATING OF THE EXISTING MAIN PV AC PANEL.
IT IS UNDER THE CONTRACTOR REASONABILITY TO VERIFY THAT THE EXISTING BUSBAR RATING WITHSTANDS THE INCOMING CURRENT FROM THE EXISTING SOLAR SYSTEM IN ADDITION TO THE NEW INVERTER.
i.e. THE BUSBAR RATING SHALL NOT BE LESS THAN 80A (PREFERABLY 100A), IF IT DOES NOT MATCH THIS REQUIREMENT, THE BUSBAR SHALL BE REPLACED

End of Solar Project Scope

End of Solar Project Scope

THIS BREAKER MUST BE AT THE VERY END OF THE INTERNAL BUSSING TO PREVENT POSSIBLE BUS OVERLOADING.

THE EXISTING CABLE FROM THE MAIN PV AC PANEL TO THE MDB, SHALL BE REPLACED BY THIS ONE

MAIN LV ROOM

EXISTING OUTGOINGS IN MDB

INJECTION POINT

100A

Surge arrester

Existing MDB in MAIN ELECTRICAL Room

INCOMING CABLE FROM UTILITY EDL/GENERATOR

SPECIAL ATTENTION SHALL BE MADE TO THE INJECTION POINT. IT IS UNDER THE CONTRACTOR RESPONSIBILITY TO VERIFY THAT THE INJECTION POINT TO BE 80A TO WITHSTAND THE LOAD AND MATCH THE NEW REQUIREMENTS.

NOTES:

REV.	DESCRIPTION	DATE

ENERGY CONSULTANT: YOUSSEF GHANTOUS

PROJECT NAME:

SUPPLY AND INSTALLATION OF SOLAR PV SYSTEMS FOR INSTITUTIONS

DRAWING TITLE:

AL NAJDA AL SHAABIA MC
ELECTRICAL DRAWINGS
POWER SINGLE LINE DIAGRAM LAYOUT

DWG NO.: NA-EL-400		REV NO.: 00
DATE: APRIL-2023		SCALE: NTS
DRAWN BY:	CHECKED BY:	APPROVED BY:
N.M.	J.B.	Y.G.

SINGLE LINE DIAGRAM GENERAL LEGEND		
Symbol	Designation	Description
		25KW THREE-PHASE HYBRID INVERTER
		Fuse protection
		DC Fuse disconnector
		PV-panels, 580Wp Mono-crystalline
		Surge arrestors for overcurrent protection
		Molded Case Circuit Breaker MCCB
		Motorized Molded Case Circuit Breaker
		Disconnect
		MCB with 300mA or 30mA RCD, as mentioned on drawings
		Power measuring device
		Solar Inverters communication and monitoring cables (STP twisted pairs CAT6A)

N.B:

THE CONTRACTOR SHALL VERIFY THE STRING SIZE / CONFIGURATION BASED ON THE FINAL SELECTED PV MODULES AND CONVERTER SUCH THAT THE STRING VOLTAGE FALLS WITHIN THE INVERTER OPERATING VOLTAGE AND MPPT VOLTAGE RAGE AND THAT THE TOTAL CURRENTS IMP AND ISC ARE BELOW THE CONVERTER MAX INPUT CURRENT AND SHORT CIRCUIT CURRENT TAKING INTO CONSIDERATION SITE MAX AND MIN AMBIENT TEMPERATURE.

Notes:

Rev.	Description	Date

Energy Consultant: Youssef Ghantous

Project Name:

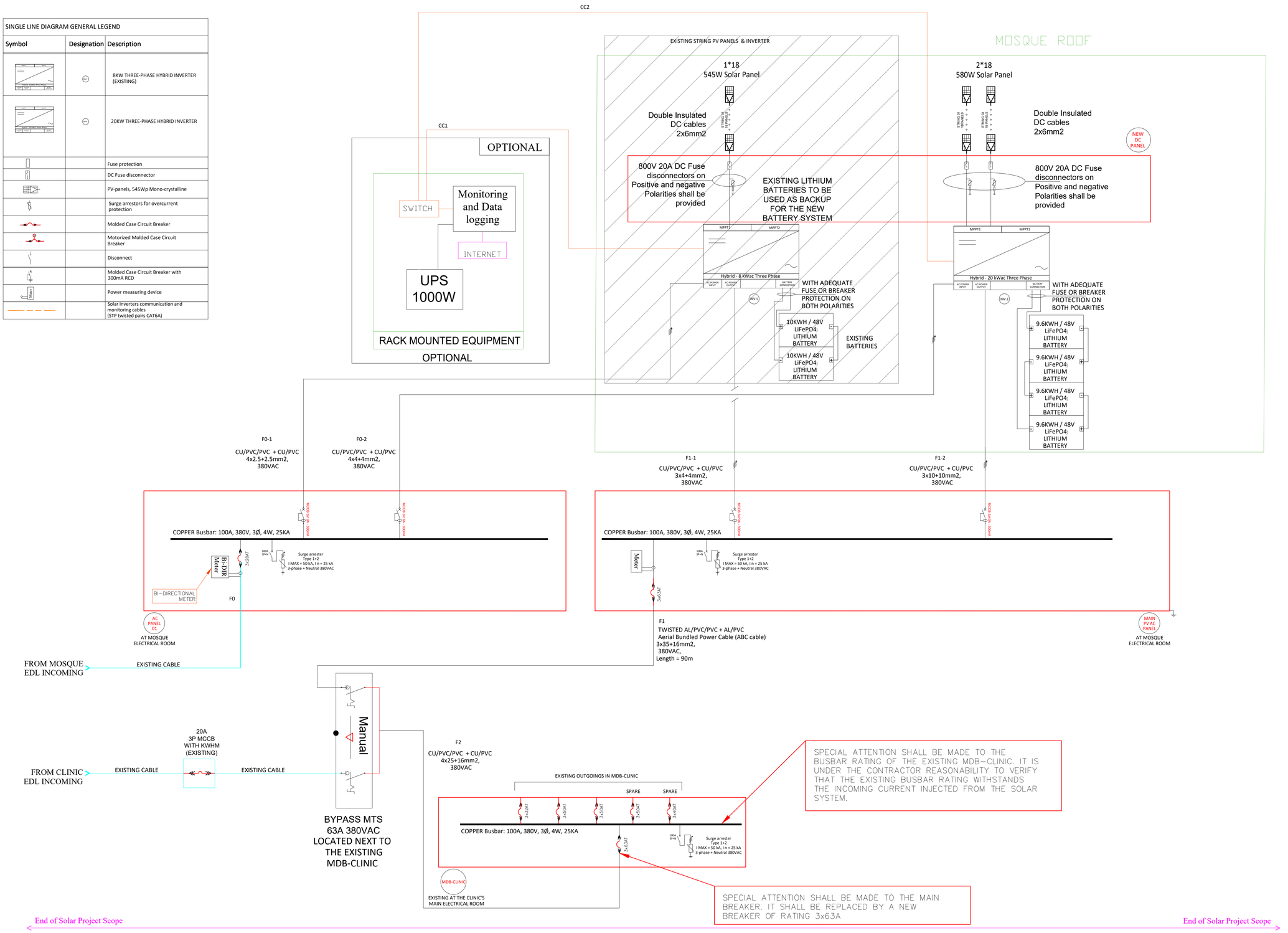
SUPPLY AND INSTALLATION OF SOLAR PV SYSTEMS FOR INSTITUTIONS

Drawing Title:

ST.PAUL MEDICAL CENTER
ELECTRICAL DRAWINGS
POWER SINGLE LINE DIAGRAM LAYOUT

Dwg No.: PMC-EL-400		Rev No.: 00
Date: APRIL-2023		Scale: NTS
Drawn By:	Checked By:	Approved By:
N.M.	J.B.	Y.G.

SINGLE LINE DIAGRAM GENERAL LEGEND		
Symbol	**Designation**	**Description**
		8KW THREE-PHASE HYBRID INVERTER (EXISTING)
		20KW THREE-PHASE HYBRID INVERTER
		Fuse protection
		DC Fuse disconnector
		PV-panels, 545Wp Mono-crystalline
		Surge arrestors for overcurrent protection
		Molded Case Circuit Breaker
		Motorized Molded Case Circuit Breaker
		Disconnect
		Molded Case Circuit Breaker with 300mA RCD
		Power measuring device
		Solar Inverters communication and monitoring cables (STP twisted pairs CAT6A)



Notes:

Rev.	Description	Date

Energy Consultant: Youssef Ghantous

Project Name:

SUPPLY AND INSTALLATION OF SOLAR PV SYSTEMS FOR INSTITUTES

Drawing Title:

AL ZAHRAA MEDICAL CENTER
ELECTRICAL DRAWINGS
POWER SINGLE LINE DIAGRAM LAYOUT

Dwg No.: ZC-EL-400		Rev No.: 00
Date: MAY-2023		Scale: NTS
Drawn By:	Checked By:	Approved By:
N.M.	J.B.	Y.G.