TENDER DOCUMENTS GRID CONNECTED PHOTOVOLTAIC SOLAR PLANT AT AZRAQ (JORDAN)

VOLUME 2

Technical Specifications for the Photovoltaic Grid Connected Plant

CONTENTS

GLOSSARY

$E_{AC,S}$	Reading of the energy meter of the static generator
$E_{AC,T}$	Reading of the energy meter of the tracking generator
E_{REAL}	Actual produced energy calculated as the difference in the energy-meter readings at the beginning and at the end of the performance ratio test.
γ	Power temperature coefficient
G	Incident solar irradiance
G^*	Irradiance at STC (1000 W/m^2)
$G(0)$	Global horizontal irradiance
G_{clean}	Irradiance measured with a clean reference PV module
G_{PVgen}	Irradiance measured with a reference PV module with same level of dirtiness than PV generator
$G_{d,S}(I)$	Global incident irradiation on the static generator
η_{EUR}	European efficiency
η_{10}	Power efficiency at 10% load
η_{50}	Power efficiency at 50% load
η_{100}	Power efficiency at 100% load
GCR	Ground Cover Ratio
$P^*_{S,N}$	Nominal power of the static generator
P^*_{N}	Total nominal power of the PV generator
$P^*_{S,IE}$	STC power of the static generator referred at the inverter input
$P^*_{G,IE}$	STC power of the generator referred at the inverter input
P_{DC}	Inverter DC input power
P_{AC}	Inverter AC output power
$P^N_{Inv,S}$	Nominal power of the PV inverters for the static generator
P^*_E	STC power of the PV module

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P_G^*	STC power of the PV generator
P_R^*	STC power of the reference modules
P_E	Power of the module under test directly measured at outdoor conditions
P_R	Power of the reference module directly measured at outdoor conditions
PR_{STC}	Performance Ratio at Standard Test Conditions
STC	Standard Test Conditions
T_A	Ambient temperature
T_C	Solar cell temperature
ΔTM	Difference between the coldest and the hottest solar cell
THD	Total current harmonic distortion

TECHNICAL SPECIFICATIONS

1.1. Objectives

These technical specifications describe the constitution and technical requirements of the PV central, the requirements for the first two-years operation and production evaluation, and the quality controls to be applied in order to assure the accomplishment of such specifications.

1.2. PV central layout

Figure 1 describes the basic electrical layout of the PV central. It is formed by one generation unit composed by a Static PV generator, a three-phase 400V_{AC} inverter, a 400V/11kV transformer with protection and measurement cell; and a 11kV connection line.

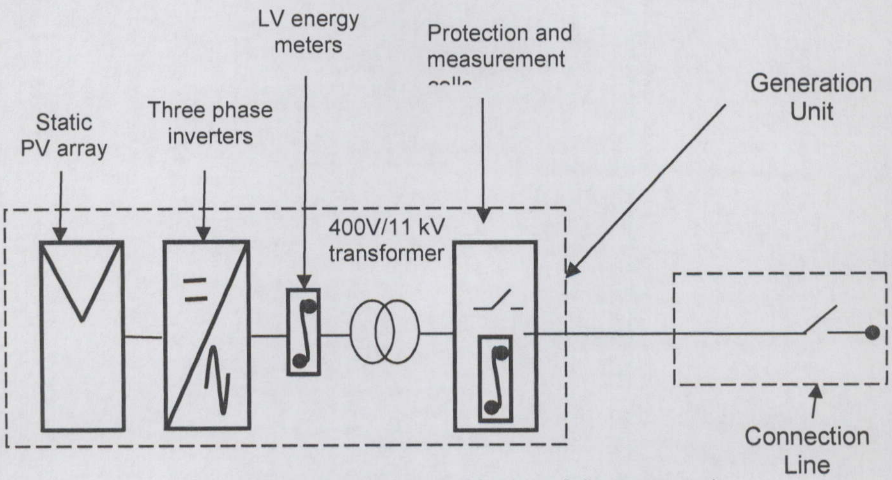
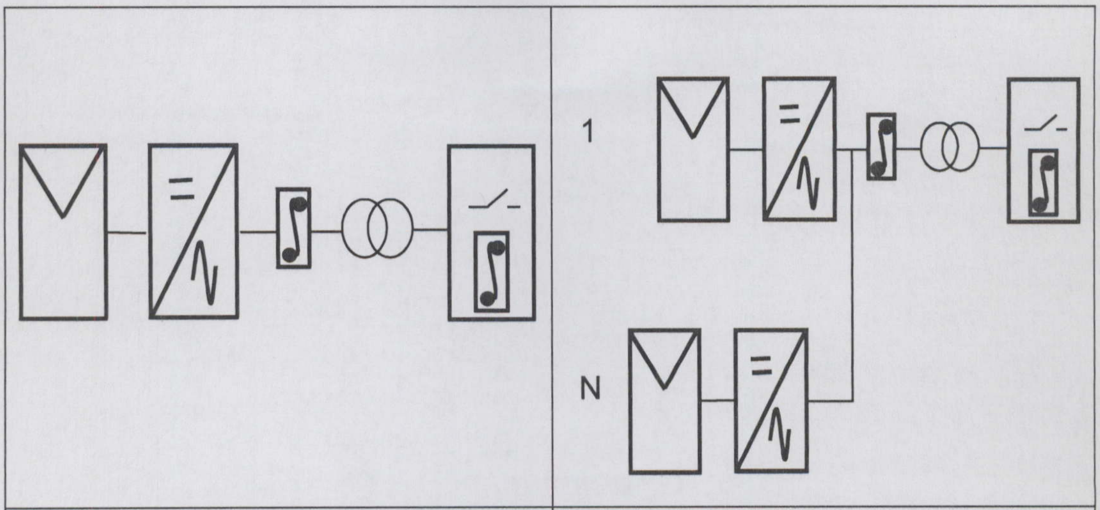


Figure 1. Basic electrical layout of the PV central

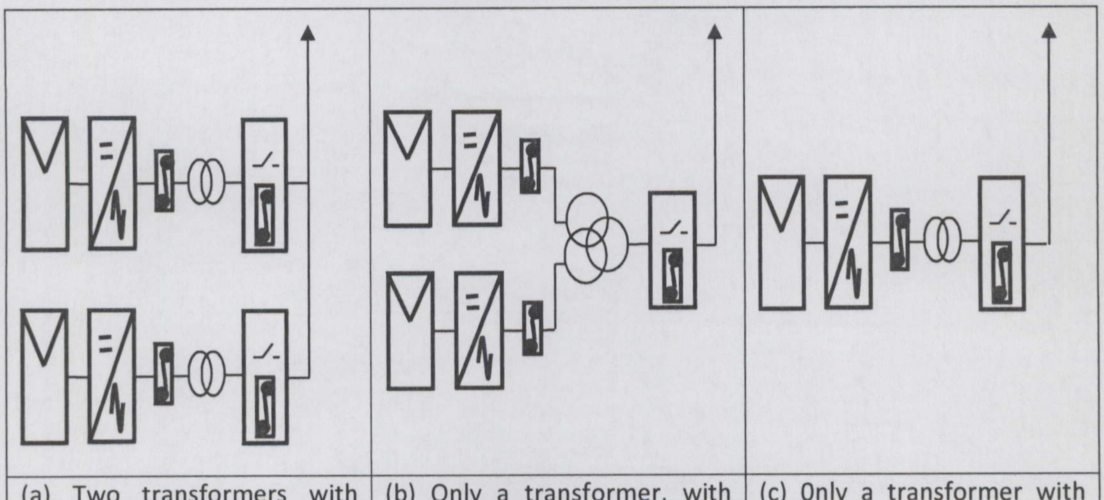
The Plant will be equipped with Static PV panels with an optimum tilt angle for south-facing surfaces. The generator unit can, at the convenience of the supplier, be composed by only one inverter or by the parallel of several inverters, each one with its corresponding PV generator (Figure 2). Whichever the case, each generator unit will only have a single LV energy meter. Even more, at the convenience of the contractor, the PV inverters can be composed by the association of mono-phase inverters.



(a) Only one inverter	(b) A number N of inverters in parallel

Figure 2. Acceptable alternatives for PV generator – inverter.

Again at the convenience of the supplier, the 400V/11kV transformers can be two different or only one. (Figure 3).



(a) Two transformers with respective protection and measurement cells	(b) Only a transformer, with two primaries, and a protection and measurement cell	(c) Only a transformer with respective protection and measurement cells

Figure 3. Acceptable alternatives for LV/MV transformers.

The connection unit is composed by an underground 11kV line from the PV central to a dedicated 11kV switch gear panel existing at the substation specific for this project. The MV energy meters will be installed by the transmission company (NEPCO) at the expense of the contractor.

In order to measure, both, ambient and operation conditions, the PV central supply also comprises six 'reference PV modules' and a standard meteorological station. Three of the reference modules are for measuring incident solar radiation and the other three are for measuring solar cell temperature. The meteorological station must include a pyranometer for measuring global horizontal solar radiation, a thermometer for measuring ambient temperature, an anemometer for measuring wind speed and wind direction.

In order to monitor and record operational data, the PV central supply comprises a single Programmable Computer dotted with a dedicated SCADA application, able of manage and record all the relevant information from PV generators, inverters, transformers, reference PV modules and meteorological station.

In order to help on the commissioning tests, the PV central supply comprises a wattmeter of high accuracy able to measure DC and AC voltage.

Finally, the PV central supply must include auxiliary services: 400V undergrounded line in order to feed the power supply up to the Auxiliary Services Board at the control building.

1.3. Technical specifications

Tenderers are requested to include a matrix format in order to indicate their compliance with each of item in these technical specifications.

1.3.1. PV generators

Nº	Specification
1	The PV generator must be constituted by identical PV modules with solar crystalline cells. These PV modules must be class II and approved according to IEC 61215, IEC 61730(Part I and II for safety qualification testing), IEC 60068-2-68 (Blowing Sand Test) latest edition . Furthermore, PV modules must be resistant against potential induced degradation (PID) according to the testing procedure described in Annex 1.
2	The STC nominal power (the number of PV modules multiplied by their nominal power, as given by the manufacturer catalogue), $P^*_{S,N}$ must not differ more than 10% of the total nominal power P^*_N. That is: $abs(P^*_{S,N}) \leq 0.1x\ P^*_N$; NOTE: according to the rules of the tender procedure, $P^*_{S,N}$ values must be proposed by the contractor in the offer.
3	The STC power referred at the inverter input (after mismatching and wiring losses) must not be lower than 93% of the STC nominal power.
4	With the PV central in operation and in the absence of shades, the PV modules must not exhibit hot spots or hot cells.
5	Preferably, as a protection measure against indirect contact, the PV generators

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	should not be earthed.
6	The strings of the PV generator must include fuses in both poles. String fuses must be rated (at 50ºC) between 2 and 4 times the STC short-circuit current.
7	The parallel of the strings of each PV generator must be made inside a connection box including the following elements: - All the string fuses - Surge arresters in both poles, and surge protection for instrumentation and control in accordance with IEC 62305. - Load-breaking switch - Current & Voltage sensors at string level - String current monitoring at string level and monitoring of the temperature inside the combiner box. - Protection from direct sunlight.
8	The connection box must be, at least, IP 65 in accordance with IEC 60529, and should be UV resistant.
9	The elements inside the connection box should be disposed in such a way that positive and negative poles are as separated as possible. This is for minimizing the risk of direct contacts.
10	DC wires from the connection box to the inverter input must be undergrounded. All DC cables shall be single-core cables and double insulated And the PV DC connectors for string interconnection shall be of the same brand and type as used by the PV module manufacturer
11	The size of each type of cable selected shall be based on minimum voltage drop, however, the maximum drop from the PV modules to the inverter input shall be limited to 2%.
12	Ground Cover Ratio, *GCR*, must be $GCR \leq 0.5$ (GCR is defined as the total PV area divided by the total system area).
13	The AC Distribution Panel Board (ACDB) shall control the AC power from inverter and should have the necessary surge arrestors. Interconnection from the ACDB to Busbar Main LV auxiliary services panel of the control building. It will made completely equipped (electrical protections and control) and a LV metering. Dedicated electrical loads shall be interconnected in this ACDB. All switches, circuits breakers, connectors are to fulfill with IEC 0947 part I,II y III.

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14	The LV cross-section cable shall be enough to transport the power from the ACDB to the Auxiliary services panel with a drop of voltage lower than 1.5%.

1.3.2. Support structure

№	Specification
15	Three foundation techniques can be considered for fixing the static PV panels: - Screwed or rammed piles. - Pre-drilled holes with backfilling or concrete - Ballast foundations
16	Support structure should be designed to withstand a wind load of 150km/hr after the installation.
17	Structural material shall be corrosion resistant and electrolytically compatible with the materials used in the module frame, its fasteners, nuts and bolts. Galvanizing should meet ASTM A-123 hot dipped galvanised, if steel frame is used. Aluminium frame structures with adequate strength and in accordance with relevant international standards can also be used.
18	All the PV modules will be kept below 4m height (for easy cleaning) and over 70cm (to avoid shades from possible vegetation).
19	The structures shall be designed for simple mechanical and electrical installation. There shall be no requirement of welding or complex machinery at the installation site.
20	The supplier/developer shall specify installations details of the PV modules and the support structures with appropriate diagrams and drawings. Such diagrams shall include, but not limited to, the following: - Determination of true south at the site - Array tilt angle to the horizontal - Details with drawings for fixing the modules - Structure installation details and drawings - Electrical grounding (earthing) - Safety precautions to be taken

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1.3.3. Inverter

Nº	Specification
21	The Inverter should convert DC power produced by PV modules into AC power and adjust the voltage and frequency levels to suit the local grid conditions.
22	The DC to AC Ratio (also known as the Inverter Load Ratio or "ILR") should be equal or lower than 1.1. (DC/AC Ratio is the STC Nominal Power of the PV Generator divided by Nominal Power of the PV Inverter).
23	The so-called "European efficiency" of the inverters must be at least 0.95. The following formula applies: $$\eta_{EUR} = 0.2 \times \eta_{10} + 0.6 \times \eta_{50} + 0.2 \times \eta_{100}$$ where $\eta_{10}, \eta_{50}, \eta_{100}$ are the power efficiency at 10%, 50% and 100% load.
24	The inverters should properly operate at their nominal power and with an ambient temperature T_A= 50ºC
25	Total current harmonic distortion, THD, should be lower than 3% (with total voltage harmonic distortion lower than 1%).
26	In order to preserve the quality of the general electricity service: - The inverters should comply with EN 61000-6-2 and EN 61000-6-4 (EMI), and also with EN 50178 (Grid quality requirements).The inverter response in case of grid voltage sags must comply with the Spanish norm P.O.12.3 or equivalent.
27	The inverters should include anti-islanding protection with automatic shut down once voltage sags requirements are fulfilled. Inverter-on after grid voltage restoring should be delayed three minutes.
28	When the power available from the PV array is insufficient to supply the losses of the Inverter, the Inverter shall go to a standby/ shutdown mode.
29	Protection against inverse polarisation, short-circuits, overvoltages, insulation failure with output to relay, should be also included.
30	The inverter must include means (shunt, toroide, etc.) for measuring DC input current with an accuracy of, at least, 0,5%. Such means must be duly certified, and

	fully accessible during reception test.

1.3.4. LV/MV Transformer, protection and measurement cells

31	LV/MV Transformers and MV protection and measurement cells must comply with the relevant international standards e.g. IEC 60076 and Jordan regulations.
32	The bidirectional electronic energy meter shall be installed for the measurement of import/export of energy
33	Preferably, inverters, transformers and protection and measurement cells should be hosted in prefabricated concrete buildings in such a way that in-field wiring and installation works are minimized.

1.3.5. Protections.

34	The system should be provided with all necessary protections like earthing, surge arresters and grid islanding.
35.A	Each array structure of the PV yard should be grounded properly.
35.B	MV circuit protection shall be complied with the grid code and NEPCO requirements.

1.3.6. Reference PV modules, meteorological station, SCADA and wattmeter .

36	Sensors for incident solar irradiance, *G*, and solar cell temperature, T_C, will be reference PV modules identical to the PV generator ones, stabilized and calibrated by a well-recognized institution (CIEMAT, IES-UPM, CENER, etc.).
37	Prior to a former calibration stage, these PV modules will be exposed to the Sun at least 50 kWh/m^2. Further calibration stages will be performed after additional exposures of 10 kWh/m^2. The PV modules will be considered stabilized when the calibration values corresponding to two consecutive stages do not differ more than 1%.
38	Generator unit shall include six PV reference modules located, in groups of two, at the extremes and the centre of one of the diagonals of the PV generator. The averages of the corresponding three G and Tc values will be the reference for commissioning testing. Moreover, during operation the cleaning of only one group

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	and the comparison of their corresponding responses will provide an estimation of dust energy impact.
39	The three PV reference modules for measuring G will be equipped with class 05 shunt resistors in such a way that the corresponding voltage for $G^*=1000\ W/m^2$ ranges from 100 mV to 200 mV. These resistors shall be installed with the same protection degree than the PV module box.
40	All the reference PV modules will be installed and fixed to the support structure in the same way than the PV generator ones.
41	The meteorological station shall include a class II thermal pyranometer for measuring global horizontal irradiance, $G(0)$, a thermometer for measuring ambient temperature, T_A, an anemometer for measuring wind speed and direction at four meters high and a Data Acquisition System.
42	The Data Acquisition System shall include additional channels enough to also record the 6 signals from the reference PV modules.
43	The meteorological station shall be close to the general services building, in such a way that the pyranometer can be easily cleaned.
44	The SCADA must receive all the relevant information from: - PV field string connection boxes. Data Acquisition System. - Inverters. - Meters. - Protection cells.Metrological weather station
45	The SCADA must include transmission facilities through GSM and also Internet. Internet connection cost and getting the required permits is the responsibility of the contractor. Contractor shall comply with NEPCO requirements regarding SCADA connection Online/remote monitoring is also required.
45.a	SCADA must include a UPS system
46	The wattmeter must have the following characteristics: - Wide voltage and current range (from 1.5V to 1000V and from 1A to 5A). - High accuracy (±0.3%) As a reference, the model of the wattmeter must be Yokogawa WT1800E or equivalent and the current probes must be Yokogawa 751552 clamp-on probe o

	equivalent.

1.3.7. Auxiliary services

47	400V undergrounded electricity supply line from the AC Distribution Panel Board to the LV auxiliary services panel of the existing control building. The LV cross-section cable shall be enough to transport the power from the ACDB to the Auxiliary services panel with a drop of voltage lower than 1.5%, LV AC power and control cables should be SWA (Steel Wire Armoured Cable) and with cable size according to IEC 60364-5-52.
48	Supply and install galvanized chain link 3mm thickness fence the clearance distance from the natural ground should be not less than 2m to the top of barbed fence angle, the chain link opening 5mm*5mm installed on 3inch diameter galvanized steel pipes every 15cm, the 3inch galvanized Hight 2m pipes install every 2m fixed in SRC plain concrete foundation ,the foundation dimension 30cm*30cm *50cm depth cast in situ method and connect the new fence with the existing fence at the beginning and end, install one side galvanized barbed fence on the 2inch diameter galvanized angles welded pipes on the 3inch pipes the welded joints should be well finished and galvanized according to the standards, FABRICATION AND WELDING ON SITE IS NOT ALLOWED, the barbed fence not less 3 lines on the angles every 15cm between lines and the thickness is not less than 2mm, taking into consideration the existing infrastructure during the excavation and grading works. The contractor should provide the details drawing, coordination, level, plot plan, method statement, mix design, country origin, samples and the cross sections for the fence and foundation for approval.

1.3.8. Civil Works

49	The civil part shall include, but not limited to, the following civil works: - Soil improvement and consolidation if necessary. - Preparation of a road from existing control building to the PV plant - Preparation of roads for proper access to all the PV arrays, connection boxes, etc. - PV generator structure foundations if this solution was selected against rammed piles. - Construction of underground cable ducts and trenches in the PV plant. - Construction of underground cable ducts and trenches between the PV plant ,the substation and the control building - Drainage system for storm water for proper infiltration to the subsoil. - Fence foundations. - Connecting the existing fire detection system to the new SCADA - Control and security system with 4 video security cameras (thermal CCTV cameras)at the plant boundary.

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50	Foundation design: the contractor shall consider the "Soil Geotechnical Analysis" included here as annex 3. The type and dimensions must guarantee the resistance to winds of 150 km/hr. The Contractor must supply notes and drawings with at least this information: - Detailed foundations characteristics (type, dimensions,...). - Reinforcement characteristics (diameter, steel grade, protection against corrosion,...) - Concrete characteristics (grade, composition,...).
51	Foundations shall be placed on virgin soil or well-compacted fill.
52	The type of cement and the concrete mix design shall be approved by the MEMR. Backfilling of all pits shall not be carried out until the MEMR have inspected and approved the foundation. In addition, the Contractor shall propose a quality assurance program with corresponding checklists for approval by the MEMR one month prior to start of construction of the foundations.
53	All cable laying and configuration of the trenches is to follow applicable international standards.
54	The MV cable shall be laid in a minimum depth of 0.90 m on a sand bed of 0.1 m thick and protected with flexible corrugated tube of an adequate section to leave 50% of its space for future needs. Refilling shall be done with appropriate material in layers of 15 cm thickness, each properly compacted. Up to 20 cm above cable crest level of the MV cables refilling material shall be sand. About 15 cm above crest level of the cables a signal band for each of the cables shall be laid; and, the routing of the cables within the Plant shall be marked by upright posts (guide marks) with plates at least every 200 m and where required for reasons for change of direction.
55	The following considerations shall be applied, when laying the LV cables: The cables shall be laid where possible in the same trench as the control cables; The trenches shall have a minimum cross-section of 0.90 m depth and 0.60 m width; Before cable laying the trench bed will require to be levelled either by making use of existing natural sandy soil or alternatively by filling with and compacting of a layer of sand; and, The LV cable shall be laid in a minimum depth of 0.80 m on a sand bed of 0.1 m thick . Refilling shall be done in layers of 15 cm thickness, each properly compacted. About 15 cm above crest level of the cables a signal band for each of the cables shall be laid. The crossings of roads shall be made through appropriate cement cable ducts or polyethylene heavy-duty (PEH) pipes, with a wall thickness of not less than 5 mm.

56	Chests or manholes must be installed every 90 m and in any change of direction.
57	Based on the climatic data and especially the rainfall data, and the Site's configuration and topography, the Contractor shall design and build a drainage system in order to protect the Plant's infrastructures against erosion and flash floods.

1.4. Commissioning

1.4.1. Testing

58	Prior to the shipment to Jordan, the PV modules will be tested to check their potential induced degradation. The test is described in Annex 1. This test must be witnessed by 4 Jordanian engineers (to be nominated by MEMR) at the expense of the contractor (flight and accommodation).
59	After an initial period of Sun exposure with the PV central working under normal operating conditions, the following tests will be carried out: - Visual and thermo-graphic inspection of the PV generator. - STC power of individual PV modules. - PV Plant Performance Ratio. - Performance ratio of the generator units at STC, PR_{STC}. - Characterization of generator units: inverter efficiency versus load, and STC power of PV generator referred at inverter input. These four tests are described in Annex 1.
60	The initial period must be long enough for the total irradiation on the PV generators to be at least 200 kWh/m^2 and, in any case, not less than one month.

1.4.2. Acceptance criteria

1.4.2.1. Potential induced degradation

61	Any PV module showing potential induced degradation according to the testing procedure described in Annex 1 will be rejected.

1.4.2.2. Visual and thermo-graphic inspection

62	Any PV module showing the "important visual faults" specified by the norm IEC 61215 will be rejected.

63	Any PV module showing hot spots higher than 100ºC will be rejected, even when it is caused by any shadow affecting the PV central.
64	Any PV module showing any difference of temperature between the coldest and the hottest solar cell, ΔTM, higher than 20ºC (G/G^*), will be rejected.

1.4.2.3. STC power of individual PV modules

65	Average STC power shall be at least 96% of the average flash power, provided by the PV module manufacturer.
66	STC power value for every individual module shall be at least 92% of the nominal power.
67	Any PV module showing anomalies in its I-V curve will be rejected.

1.4.2.4. Performance ratio

68	The result of the test will be considered successful if the PR_{STC} value is higher than 0.85

1.4.2.5. Characterization of generator units

69	The result of the PV generator power test is considered successful if the STC power referred at the inverter input (after mismatching and wiring losses) is not lower than 93% of the STC nominal power (the number of PV modules multiplied by their nominal power, as given by the manufacturer catalog).
70	The result of the inverter efficiency test is considered successful if the measured European efficiency is $\eta_{EUR} \geq 0.95$

1.5. First two years of operation

71	The supplier shall operate the PV central, under its exclusive responsibility, during the first two years after commissioning.
72	Cleaning: in order to manage with dust, often present in this area: • One of the three reference PV modules measuring G in the generation unit shall be routinely cleaned every day, while the two others shall be kept as the corresponding PV generator. This way, the difference between G_{clean} and G_{PVgen} (averaged) provides estimation for dirtiness degree.

	• Each entire PV generator shall be cleaned when the respective dirtiness degree reaches 5%
73	The supplier shall send monthly operation reports to the MEMR, including: • Daily values of global horizontal irradiation, Gd(0), global incident irradiations, $G_{d,S}(I)$ and $G_{d,T}(I)$, dirtiness degree at midday, and energy meters readings, $E_{AC,S}$ and $E_{AC,T}$. • Incidences: description, corrective actions, duration and energy impact estimation • Raw data from SCADA.
74	The energy availability all along this year shall be at least 97%. Over the year the PV Plant is to achieve a PR higher than 80%. After the end of each year of O&M Contractor is to submit O&M report focused on Availability & PR over the year.

1.6. Spare parts

75	The contractor shall have all spare parts necessary to support the PV Central in the O&M period. At the end of the second year operation, at least the following spare parts shall be delivered: • 0.5% of the total PV modules. • 0.5% Mounting structure.5% of the total existing fuses, circuit breakers and minimum one piece per each. • A complete inverter kit (inverter block, switchers, fuses, fans, control cards, etc.). • Tools and Tackles for maintenance purpose

1.7. Manufacturer Warranties: the effectiveness of each warranty shall start from the successful commercial operation date (COD) and shall stand for the periods as mentioned below:

76	PV modules: - STC power losses:

	First year (from COD): 3%; Ten years: 10%; 25 years: 20% - Product: 10 years
77	Inverters, transformers and protection units: - 5 years
78	Meteorological station and SCADA: - 3 years
78.a	Main Transformer : - 5 years
78.b	PV module mounting structure: - 10 years

1.8. Training

79	The contractor shall train 4 engineers/technicians (will be nominated by MEMR), at the extent they can properly operate and maintain the PV central in the years to come.
80	For that, these engineers/technicians shall be integrated into the supplier team, in charge of the installation and first two years of operation.

1.9. Location

81	The PV central will be located at MEMR terrain in Azraq area, 70 km East of Amman, beside a grid substation owned by NEPCO. See Annex 2 for the map of the location. The solar radiation and ambient temperature data for a nearby site called Um Jemal is available in Annex (4).
82	Land availability for the PV central is detailed in the drawing of the Annex 2.

1.10. Documentation

83	The supplier must provide all the documentation described in IEC 62446:2009.

Annex 1
Commissioning tests

A1.1 Potential induced degradation

84	Prior to the shipment to Jordan, five randomly selected PV modules will be tested to check their PID reliability according to the following procedure: - Temperature of 25ºC. - I-V measurement in accordance with IEC60904-1 before PID. The result will be the P^*_{mod}. - Full-area coverage of the module's front surface with aluminium foil or water. - A voltage of -1000V applied between the cell matrix (via the junction box) and the front surface. - Degradation period of seven days. - I_V measurement in accordance to IEC60904-1 within four hours after finishing the test. - A maximum of 5% of P^*_{mod} degradation shall be allowed.

A1.2 Visual and thermo-graphic inspection

85	The difference of temperature between the coldest and the hottest solar cell of every PV module, *ΔTM*, will be observed by a thermo-graphic camera. The concerned generator unit shall be in normal operation, that is to say, feeding power to the grid.
86	Simultaneously, the on-plane irradiance, *G*, will be registered.
87	The conditions for the test result to be considered valid are the following: a. On-plane irradiance higher than 750 W/m^2 b. Irradiance variation during the previous 10 minutes less than 20%.

A1.3 STC power of individual PV modules

88	Forty randomly selected PV modules will be tested without removing them from the support structure, just by disconnecting from the PV generator. A reference PV module will be placed close to the PV modules under test, in such a way that both reach the same temperature.
89	Two I-V curves, one of the module under test and the other from the reference PV module, will be recorded by means of a capacitor load. Capacitor charging time will be at least 20 ms. The STC power value will be given by: $P_E^* = P_R^* \frac{P_E}{P_R}$

	where: P_{E}^{*} is the STC power result. P_{R}^{*} is the STC power of the reference modules P_{E} is the power of the module under test directly measured at outdoor conditions. P_{R} is the power of the reference module directly measured at outdoor conditions.
90	The conditions for the test result to be considered valid are: a. On-plane irradiance higher than 700 W/m^2 b. Ambient temperature less than 40ºC. c. Wind speed less than 5m/s.

A1.4 Performance ratio at STC, PR_{STC}.

91	The test principle consists on the simultaneous observation of the operating conditions: on-plane irradiance, *G*, and cell temperature, T_C; and on comparing the estimated energy with the actual produced energy, the last one calculated as the difference in the energy-meter readings at the beginning and at the end of the test, E_{REAL}
92	The minimum period for the test must be five consecutive days. Measurements must be registered from the daybreak until sunset. The test duration must be long enough to fulfil the condition of at least 24 hours of on-plane irradiance higher than 700 W/m^2.
93	During the test period, any action affecting the degree of dirtiness of the PV plant and sensors must be avoided. Other maintenance works can be done if they are carefully registered (cause, task and duration) and included in a special operating report for the test period.
94	*G* and T_C will be recorded at least once per minute.
95	The value of PR_{STC} will be from: $$PR_{\mathrm{STC}} = \frac{E_{\mathrm{AC}}.G^{*}}{P_{\mathrm{RF}}^{*}\Delta t\sum_{i} G_i\left[1+\gamma(T_{\mathrm{C},i}-T_{\mathrm{C}}^{*})\right]\left[1+c\cdot\ln\frac{G_i}{G^{*}}\right]}$$ where G^*=1.000 W/m^2 , T_{C}^{*} =25º C, Δt is the data time resolution (1 minute or less), *i* is the time index for all the test period, γ is the power temperature coefficient, whose value is negative and it is provided by the PV modules manufacturer, and *c*=0.031 (value corresponding to $\frac{\eta_{200}}{\eta_{STC}} = 0.95$)

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A1.5 Generator units characterisation

96	The test principle consists on the simultaneous observation of the operating conditions: on-plane irradiance, G, cell temperature, T_C; and the inverter DC input, P_{DC}, and AC output power, P_{AC}. The test shall be applied to the two generator units.
97	P_{DC} must be measured with a high quality wattmeter. For DC currents higher than the measurement range of the wattmeter, the means for measuring DC input current established in the specification 30 will be used.
98	The minimum period for the test must be two consecutive days. Measurements must be registered from the daybreak until sunset. The test duration must be long enough to fulfil the condition of at least 4 hours of irradiance level higher than 700 W/m².
99	During the test period, any action affecting the degree of dirtiness of the PV plant and sensors must be avoided. Other maintenance works can be done if they are carefully registered (cause, task and duration) and included in a special operating report for the test period.
100	G, T_C, P_{DC} and P_{AC} will be recorded at least once per minute.
101	For every set of values (G, T_C, P_{DC}) not affected by anomalous effects (shadows, inverter shut down, etc.) and fulfilling the condition G> 600 W/m², the DC PV generator power at the standard temperature, $P_{DC,25}$ must be calculated with the following equation: $$P_{\mathrm{DC},25} = \frac{P_{\mathrm{DC}}}{\left[1+\gamma(T_{\mathrm{C}}-T_{\mathrm{C}}^{*})\right]}$$ where G^*=1.000 W/m² and T_C^* =25º C, and, γ is the power temperature coefficient.
102	The STC power result, $P_{\mathrm{G,IE}}^{*}$, is the value providing the best fit of the straight line $P_{DC,25}$ = $P_{\mathrm{G}}^{*}.(G/G^*)$ to the set of points resulting of the equation of the previous clause. (Note that $P_{\mathrm{G,IE}}^{*}$ represents $P_{\mathrm{S,IE}}^{*}$)

A1.6 PV Plant PR

103	**PR**

$$PR = \frac{Production\ energy}{Expected\ energy} = \frac{Production\ energy}{\sum_t \left[Irradiance\ [\frac{Wh}{m^2}] \times \frac{Peak\ power\ [W]}{1000\ W/m^2}\right] \times \left[1 + (Temp\ [°C] - 25°C) \times Temp\ Coefficient\ [\frac{\%}{°C}]\right]}$$

Annex 2
Location map

Bidders shall make technical proposal for the PV Plant technical proposal in the area of the drawings marked as proposed land.

- AZRAQ II Area Plan.pdf

Annex 3
Azraq Soil Report

Annex 4
Solar Radiation Data at Um Jemal