

A) Scope of Work

The scope of work will include supplying, delivering, installing, testing, commissioning, operating, handing over and maintaining four (06) solar water-pumping systems in Taiz Governorate for drinking water supply to rural and urban communities.

If there is any difference between these guidelines and the BoQs, the BoQs will be the right reference.

Each solar water pumping system mainly consists of, but not limited to, the following:

Solar PV modules array, submersible motor-pump set, submersible cables, electronics controller (VFD/Solar Pump Inverter), wiring / cabling, mounting structures and all necessary civil works. The Contractor shall carry out all the works of supplies, installations and operation of solar pumping systems with all accessories. In addition, replace the old submersible pumps with new ones with all civil works necessary for the successful operation as detailed herein.

The previous works shall be performed in full in accordance with the quantities and technical specifications of the goods and works described in this document and under the supervision of INTERSOS site Engineer and according to what is customary.

The work to be performed under these specifications includes provision of all labor, materials, tools and equipment necessary to install the array support structure and submersible pump set. etc. as a complete work and shall be in consultation with the assigned inspector.

The scope of works mainly shall include but not be limited to the following activities:

- Lifting old submersible motor-pump sets with all its components from the mentioned wells).
- Supply, installation, operation, and commissioning of Six (6) new submersible motor-pump sets with all its components and accessories required for success operation.
- Supply, installation, operation, and commissioning of Six (6) solar PV system solutions with all accessories for all submersible motor-pump sets mentioned above.
- Supply, installation, operation, and commissioning of panels at these locations.

Design Requirements and Guidelines:

The contractor is responsible to carry out the detailed design works according to the technical specifications and drawings for the PV Solar systems in the 3 different specified locations, as per the following requirements:

This specification covers the design, material, construction features, manufacture, inspection, testing the performance of submersible pumps.

All pumping units shall be designed and built for continuous service without over-heating and cavitation.

B) Solar Panels

B.1) PV Modules

PV cells should be of grade A

- Module capacity should not be less than 330 W @STC;
- Type of cell: Poly or Mono Crystalline, 5 bus bar technology;
- The PV manufacturer should be approved as tier-1;
- Module efficiency: should not be less than 18%;
- No of cells in each panel: not less than 72 per panel;
- Tolerance of maximum power rating: 0-5 W;
- The PV modules junction box must be IP67;
- Module Voltage: Not less than 1000 VDC;
- Operating temperature: -40°C to 85°C;
- Nominal operating cell temperature (NOCT): 45 ±2°C;
- Module frame: Aluminum or Stainless steel
- High transmittance tempered glass: Minimum thickness of 4.0 mm;
- Must conform to IEC 61215, 61730, 61701, and UL 1703.TUV, UL certificates or equivalent; Bidders shall provide Certificates and data sheet of PV module that contains the P-V & I-V Curves, all electrical and mechanical data, dimensions, and module area. Flash test certificate is required for at least 3 panel samples

- Performance warranty: Nominal power output 90% for 10 years, 80% for 25 years;
- Product warranty shall be at least 10 years.

B.2) Solar Pumping Drive

The drive should have a long lifetime, low maintenance cost, built in MPPT and VFD (Variable Frequency Drive).

Three Phase output, voltage range 380-420 V;

Efficiency: Not less than 95%;

Output Frequency: 50Hz±3%;

Enclosure class should be not less than IP 55 for inverter up to 37 kW;

Enclosure class should be not less than IP44 for inverter 45 kW or higher;

Maximum input voltage (Voc): not less than 850 VDC;

The system should be designed to run near its MPPT range;

Operating temperature: up to 50 °C;

Built in data loggers;

The device shall allow hybrid operation with external power source, where solar power should be configured as the primary power source.

Soft start, V/F stable speed control during solar radiation changes, adjustable auto/manual start in early morning, auto wakeup after adjustable hibernation time in cloudy days, inputs for pressure switch and water level sensor to protect the pump against dry running and tank full water or closed pipeline (high pressure)

Display: LCD Screen display with Cover and LED status indicator;

Protection: over-voltage, over-temperature, pump phase failure, overload, pump short-circuit, ground fault, solar low power, DC Input Anti-reverse, AC output unbalance;

Display content: PV status (Current, Voltage, Power, Energy), AC input voltage, AC output voltage, Load, Running Status, RPM, and Frequency Product warranty should be at least 2 years.

B.3) PV Combiner Box

The PV combiner box should be used to combine the multiple DC input to one output, and it shall comply with the following specifications as minimum. Enclosure materials: Coated metal with lockable front door.

Enclosure protection: IP65;

Number of input circuit: Total number of strings in addition to 2 spare inputs.

DC fuse rating for each string: 1000V, 15 A. Built in surge protection device; Anti-backflow diodes.

Operational Environment Temperature: -30 °C ~+70 °C;

Product warranty shall be at least 2 years.

B.4) System Cables

Cables should be sized in accordance with IEC 60364-5-52 standard, bidders should submit cable sizing, and voltage drop calculations taking into account that the maximum voltage drop should be no more than 2% for each side (AC and DC);

B.4.1) 3 phase, AC Submersible Pump Cable

Voltage rating 450/750VAC, Type of Conductor: copper, flexible, finely multi stranded, Insulation: black poly chloroprene, HO7RN -F or equivalent material

B.4.2) DC Cable (From array to Combiner Box)

Made of double insulation material and jacket, TUV certified, 1000VDC, Sheath colours: black, red,

Type of Conductor: tinned copper, flexible, finely multi stranded

B.4.3) DC Cable (From Combiner Box to inverter)

Made of double insulation material and jacket, TUV certified, 1000VDC, Sheath colours: black, red, type of Conductor: tinned copper, flexible, finely multi stranded

B.4.4) Water level Cable with Sensor

Submersible cable, 1 × 1.5 mm² mm, double sheath.

Dry running electrodes

B.4.5) PVC Conduits for Cables holding

Must be used for wires and cables with all required accessories such as spacers, saddles, couplers, and bends, inspection or non-inspection type elbows, tees, junction box(s) of required ways and resin/adhesive to make all joints rigid.

Conduits type: Rigid PVC.
 Thickness: not less than 3mm.
 Diameters: depending on the quantity of the cables to be installed.

C) Grounding System

C.1) DC Grounding

All PV modules shall be grounded in accordance to the manufacturer instruction;
 Earthing clamps shall be used;
 Grounding and lightening protection equipment shall include SPD, earth pits and rods
 Grounding resistance should be less than 5 ohms;

C.2) AC Grounding

All components shall be grounded including motor, pump, chases in accordance to the manufacturer instruction.
 Grounding and lightening protection equipment shall include SPD, earth pits and rods Grounding resistance should be less than 5 ohms.

D) Pumping Controller System

Including Smart Inverter device shall allow hybrid operation with external power source(2 Mppt input trackers, AC output, 3 phase, grid voltage 400 according to local grid standards, the inverter is capable to operate with standby generators 400 kVA/1200kVA isolated from the grid, Rated frequency 50, HZ, Rated Efficiency 96% and Ground fault indicator, power factor range from 0.95 inductive load to 0,95 capacitive load, islanding protection), The inverter is capable to display:

- AC voltage
- AC output current
- Output power
- DC input voltage
- DC input current
- Time active
- Time disabled
- Time Idle
- temperatures (C)
- Converter status

Protective function limits (i.e AC over voltage, AC under voltage,

Over frequency, under frequency, ground fault, PV

Starting voltage, PV stopping voltage, over voltage delay, under voltage delay, ground fault delay, PV starting delay, PV stopping delay.

Where solar power should be configured as the primary power source; drive a three-phase AC/DC motor-pump system, a DC to AC inverter with variable frequency drive (VFD) is used. Convert DC current from panels to AC for the pump MPPT, Pump Controller, Frequency Drive, Dry Running Sensor, Filter, Circuit and KWH meter.

E) Submersible Pump

Submersible pump, mixed flow multi -stage separate type, AC 3PH motor type, the motor pump sets should be used for the solar PV, starting compatible with AC VFD operation, bidders shall indicate manufacture, country of origin and model. It shall follow below features as minimum:

Cooling sleeve suitable for borehole well internal diameter

Pump Efficiency at Duty Point: Not less than 70%;

Clearance (well dia-pump max dia with cable) = not less than 40 mm;

Casing (Pump Bowl), Impeller, Wear Rings, Pump delivery and Housing, check valve (None Return Valve),

Inlet strainer should be complied with: (AISI 304 or equivalent) or higher specification materials.

Shaft and coupling, shaft sleeve, bearing bush, guide bearing, screw, stud, nut, washer, etc. should be complied with: (AISI 304 or equivalent) or higher specification materials.

Maximum allowable sand: 100gr/m3. Coupling: according to NEMA.

F) Motor

The motors shall be rewindable frame, insulation rating is compatible with AC VFD operation

Rated Voltage 380/400VAC

Insulation Material and Class, PE2+PA, F or H

Ambient water temp: 45 C

IP: not less than 58

Motor Efficiency: Not less than 80%

Motor Speed: 1850rpm – 2850rpm

Shaft, Motor Sleeve, Motor Housing, Diaphragm cover, bolts, Nuts, Studs, screws, washers, etc. should be complying with: (AISI 304 or equivalent) or higher specification materials.

Shaft Seal (Mechanical Seal) Tungsten carbide/ceramic- Diaphragm Nitrile Rubber Radial Bearing

(Guide Bearing) Graphite or superior Axial Bearing (Thrust Bearing) Graphite/ S.S Pads superior,

Rubber Parts NBR or equivalent

Product warranty should be at least 2 years.

G) Mounting Structure

All elements sections shall be A36 steel with minimum yield stress 248MPa.

The HSS purlins shall be hot dipped galvanized steel and fixed by stainless steel self-drilling fasteners as detailed in the shop drawings.

For columns with a section of IPE100, their foundations are (0.45x0.45x0.6) m isolated footings reinforced concrete type C25 with reinforcement bars as shown in the shop drawings The reinforced concrete with proportion cement/ sand/ gravel 1: 1.5: 3 respectively.

The concrete must be mechanically mixed by a machine.

The reinforcement bars shall be with minimum yield stress 280MPa.

The weight of the fixing concrete blocks should be not less than 72 Kg per module.

Welding of galvanized elements is not allowed.

Welds to steel for mounting shall be full depth fillet welds unless otherwise stated in the shop drawings.

The bolts shall be approved make with nuts of various diameters and lengths, Class 8.8 Type for joining of various Structural components like Column,

The first coat shall be from approved zinc chromite primer which applied by using mechanical spaying as well as final two coats of synthetic enamel paint over mounting elements except the galvanized elements as directed.

H) Security Fence

Metal Fence with barbed wires as per the shop drawings and the technical specifications (17), the work includes the following:

Provide materials and construction of 2.50-meter-high chain link fence made from galvanized /or anticorrosion iron Post 50 & 65mm DN that shall be embedded in concrete footings (30x30x60) cm C20 and pressed at end. The panels width is 3 meters. The chain link 50mmx50mm opening and 3.15mm dim, the work includes installing of three lines of Barbed Wires above.

Double leaf gate 2m in width, poles DN 65mm 2.5-meter height with BRC link 75mmx75mm spaces with all requirement.

I) Location

The targeted three wells are located in rural areas of Al-Ma'afer and Al-Shamayatain Districts in Taiz Governorate. The map and table below show the location and coordinates of the targeted water wells to be supplied with solar pumping systems and their location in Al-Ma'afer and Al-Shamayatain Districts. Wind speed is expected to reach a maximum of 126 Km/hr.

The table below summarizes wells detail information, location and coordinates

#	Well Name/ Location	Type of intervention	Targeted beneficiaries/ Person	E	N	Governorate / District
1	Al-Nashamah	Solar Unit and Pump Set	20,373	13.38143395	, 43.96686053	Taiz Governorate, Al-Ma'afer district
2	Al-Sha'oba	Solar Unit and Pump Set	23,332	13.388001	44.023282	Taiz Governorate, Al-Ma'afer district
3	Al-Mashariqa	Solar Unit and Pump Set	7,520	13.52379	43.96651	Taiz Governorate, Al Shamayatain district
4	Qahft Al-Dageney	Solar Unit and Pump Set	6,854	13.238959	44.136093	Taiz Governorate, Al Shamayatain district
5	Jannat	Solar Unit	9,310	13°56"46.09'	44°00"21.62'	Taiz Governorate, Taiz City
6	Gharb Sina	Solar Unit	15,344	13.56696	43.999663	Taiz Governorate, Taiz City

#	Governorate/District	Well Name	Capacity of water tanks installed (m3/d)	Well casing diameter (inch)	Water needed m3/d	Total Dynamic Head (m)	Pump Installation Depth (m)	Type of raiser pipes	Raiser pipes diameter (inch)	Pump Motor rating (Kw)	Required Pump Motor Working Hours (H) – Solar and/or Hypered	Required Pump Motor Working Hours/ using solar power system	Inverter Power (Kw)	PV Array Size (KWp)	Total No. of Solar Models	Capacity of the installed engine
1	Taiz Governorate, Al-Ma'afer district	Al-Nashamah	75	10"	305.5	216.5	210	GI	3"	26	10	5-8	37.7	39	118	60 Kw
2	Taiz Governorate, Al-Ma'afer district	Al-Sha'oba	100	N/A	350	288.45	3	G1	4"	30	9.45	8	43.5	45	136	150 HP
3	Taiz Governorate, Al Shamayatain district	Al-Mashariqa	350	12"	112.8	280.8	170	GI	3"	26	8	8	37.7	39	118	88 Kw
4	Taiz Governorate, Al Shamayatain district	Qahft Al-Dageney	75	8"	102.8	185.66	108	GI	3"	18	8	8	26.1	27	82	160 HP
5	Taiz Governorate, Taiz City	Jannat	5500	8"	136.59	150	130	GI	3"	11	10	8	15.95	16.5	50	250 Kw
6	Taiz Governorate, Taiz City	Gharb Sina	5500	8"	230.16	226.5	220	GI	3"	26	16	8	37.7	39	118	



#	Well Name	Well Depth (M)	Well Case Diameter (Inch)	Static Water Level (M)	Dynamic Water Level (M)	Pump Installation Depth (M)	Required Flowrate (m3/h)	Total Dynamic Head (TDH)	Height of Water tank base (M)	Total elevation of water tank from the surface of well (M)	Water Quality Test Result	Area for PV Arrays M2
1	Al-Nashamah	230	10"	184.20	186.78	210	30.36	216.5	0.8	3.8	Acceptable	320
2	Al-Sha'oba	N/A	N/A	N/A	260	3	30	288.45	0.8	253	Acceptable	370
3	Al-Mashariqa	225	12"	94.25	138.80	170	18	280.8	0.8	100	Acceptable	320
4	Qahft Al-Dageney	140	8"	91.60	92.40	108	18	185.66	0.8	63	Acceptable	221
5	Jannat	143	8"	50	109.22	130	15	150	0.8	20	Chlorinated	135
6	Gharb Sina	236	8"	48.50	131.55	220	15	226.5	0.8	52	Chlorinated	320

Climate and Weather

Yemen lies in the sunny region of the world. Most parts of Yemen, including Taiz Governorate, receive 5-7 KWh/m²/day of solar radiation per m² per day with 300-325 sunny days in a year.

The average rainfall recorded fluctuated between 0 to 110 mm/day, the average annual temperature ranges between 15 °C and 23 °C. The hottest season is from June to August and the coldest season is from January to February.

The average monthly relative humidity varies from 40 % to 65 % while the mean annual duration of sunshine hours is 8.9 h/day. The average wind speed is 2.7 to 3.5 m/sec in the winter and 2.9 to 4.8 m/sec in summer.

Number of hours of actual solar brightness in Taiz governorate.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average (H/D)
Taiz	8.4	8.7	9.1	8.7	8.8	7.4	7	7.6	8	9.4	9.5	8.7	8.4

Average daily solar radiation (MJ / m² * day) in Taiz governorate.

	Winter			Spring			Summer			Autumn			Average (MJ/m ² * day)
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
Taiz	17.8	18	20	21.2	21.8	21.8	19.1	18.3	19.5	21.4	20	20.3	19.9

Note: Data from the meteorological department of monitoring records during the year 2015 approx.