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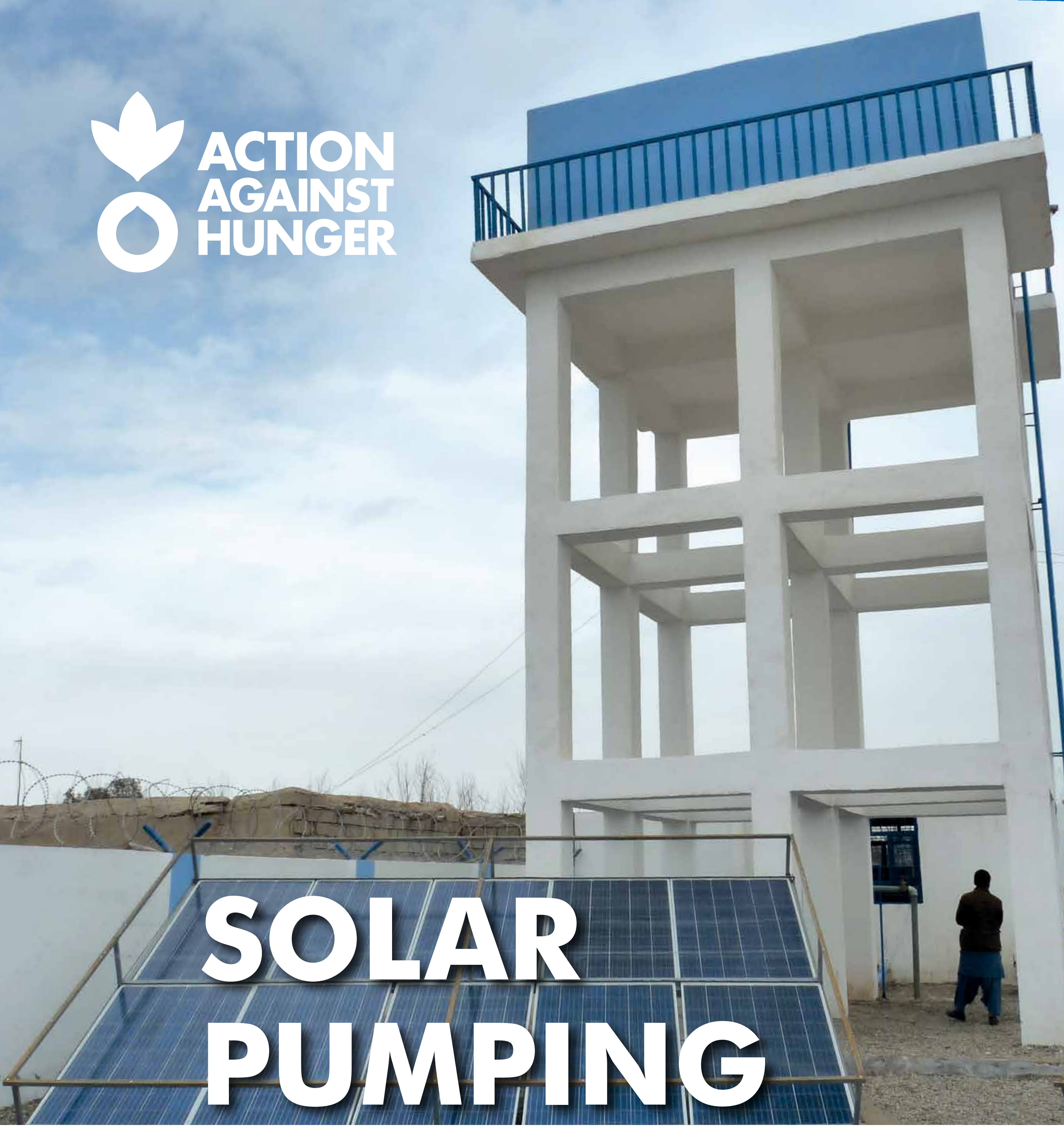

SOLAR PUMPING

ELECTRICAL DESIGN AND INSTALLATION OF SOLAR PUMPS

GUIDELINES

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SOLAR PUMPING

GUIDELINES FOR ELECTRICAL DESIGN AND INSTALLATION OF SOLAR PUMPS

ACRONYMS

ACF	Action contre la Faim
AAH	Action Against Hunger
DC	Direct Current
AC	Alternating Current
PMAX	Maximum Power
STC	Standard Test Condition
NOCT	Normal Operating Cells Temperature

FIGURES

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In a world where the challenges of greenhouse gas emissions and preservation of the environment are ever more significant, and in which the challenges of access to water resources require sustainable and efficient solutions, Action Against Hunger recommends solar pumping approaches to its Water Sanitation and Hygiene (WASH) and Food Security & Livelihoods (FSL) project managers and project coordinators to consider solar pumping approaches.

Easy to design, environmentally friendly, affordable to invest in and very low cost to operate, solar solutions have many programmatic advantages, and increasingly attracts actors from the humanitarian world, communities of users as well as donors.

This guide will help you design your solar pumping projects.

As you go through these guidelines you will learn that it is not necessary to provide too many technical details in quotations. However, it is necessary to specify the expected outcomes of your solar pumping system, including:

- the required quantity of water to be pumped per day,
- at which height (total head),
- with the option of connecting to a power generator,
- addressing safety with a protective box including fuse, surge arrester, disconnect button, a low level detection probe inside the borehole, and grounding,
- With options if applicable (quality of solar panel support, remote reading of water level, backup power generator ...).

Using the simplified calculation formulas (Chapter 2), you will be able to verify the sizing of the system as proposed by the supplier(s), and ascertain whether the number of panels, the power of the pump and the power of the generator set are correct.

If you encounter any problems, or if you have not been able to verify the sizing, then request support by sending an email to: energyrequest@actioncontrelafaim.org *(Only for feedback from ACF staff)*

Upon completion of the works, you will receive the pumping system using the attached form in Annex 4, and request the necessary modifications to ensure that the system is fully in line with your expectations.

You will finally complete the training to the users, or the installer will do it. The management committee of the pumping site will be responsible for the newly created pump system. Users need to know maintenance operations to be performed and who to contact in case of failure or need for spare parts.

If you read this documentation after completing your project, and have made mistakes, it is not too late. It is always possible to carry out corrective works, which is generally inexpensive. To do this, you need to identify the modifications to be carried out, task by task, consult the suppliers to obtain the new parts and carry out the modifying work.

If you have any doubt, do not hesitate to ask for technical support, send pictures of installations made and / or systems that you think you have to modify, or get supplier offers validated, via the email address: energyrequest@actioncontrelafaim.org *(Only for feedback from ACF staff)*

Solar energy is a tremendous asset in enabling project beneficiaries to have reliable access to water with minimal operating costs, but only provided that the pumping system is safe and equipped with quality components, ensuring the sustainability of new facilities.

A/

SOLAR PUMPING TYPES, COMPONENTS AND OPTIONS

A/ SOLAR PUMPING TYPES, COMPONENTS AND OPTIONS

1. SOLAR PUMPING TYPES

There are 3 main types of solar pumps whose standard curves are presented below:

① **Motorized hand pumps.** This is the same mechanism as the one used in manual pumping (piston and rods, «India Mark» type), on which an engine/motor is added to replace human operation.

② **« Solar pumps »** powered directly via a suitable pump controller, that should be supplied by the pump manufacturer to ensure compatibility.

③ **Conventional pumps** (usually powered by generator) that will be powered via a variable frequency inverter, commonly called « solar pumping inverter ».

FIGURE 1: SOLAR PUMPING SCHEMES ACCORDING TO WATER FLOW AND TOTAL HEAD

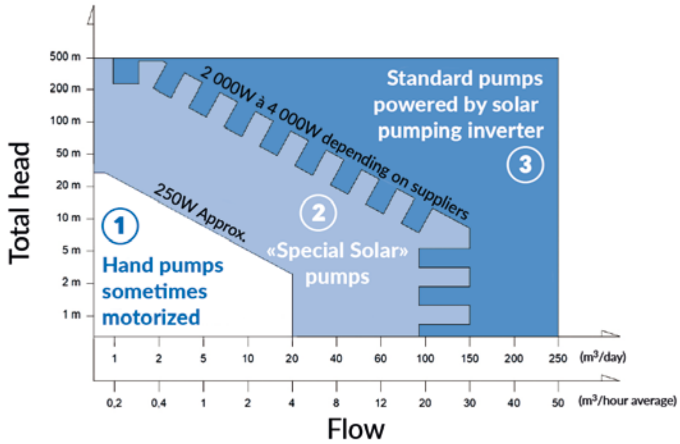
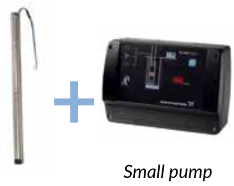


TABLE 1: BASIC CONFIGURATION ACCORDING TO FLOW AND TOTAL HEAD

CONFIGURATION	Motorized hand pumps ①	"Special Solar" pumps ②	Conventional pumps ③
Power	< 250 W < 0,35 HP	250 W to 4 000 W *(max 2 000W only for some suppliers)* 0,35 HP to 5 HP	> 4 000 W > 5 HP
Solution	**Manual pumps.** *For irrigation applications (long pumping duration), there are "motorized" manual pumps that offer the advantage of keeping a manual mode in case of problems.*	**« Solar » pumps, to be procured with their control box.** *Possible to find AC or DC pumps.*	**Standard pump, powered by solar pumping inverter.** *The pumps are powered with three-phase alternating current (AC) and variable frequency in the very large majority of cases.*
Type of Equipment (examples)		 *Small pump controller.*	 *Solar pump inverter.*
Example of brands and ranges of main suppliers	**VOLENTA:** *- One pump in the range but price and performances depends on borehole depth.*	**GRUNDFOS:** *- Range SQFlex* **LORENTZ:** *- Range PS2*	**GRUNDFOS:** *- Range SP for the pump* *- Range RSI for the inverter* **LORENTZ:** *- Range PSk2 (pump and inverter)*

Solar photovoltaic pumping is increasingly used within Action Against Hunger programs. It is being implemented in various environments where electrical skills are often not available, and recurring mistakes have been observed in the design and during system installation.

This guide provides an overview of solar photovoltaic pumping, introducing basic sizing rules so you can self-check the number of panels proposed by a subcontractor and avoid common mistakes made by unskilled designers. Some of the most common mistakes are shown in Table 2 below.

TABLE 2: MAIN DEFECTS REPORTED DURING AND AFTER PROJECT IMPLEMENTATION

OBSERVED MISTAKE	SOURCE OF THE MISTAKE	CONSEQUENCE
Wrong type of pump	The designer designs the solar system as a standard pump system (with generator), and simply indicates in the specifications that the source must be solar.	System underperformance. Equipment supplied does not conform to solar pumping requirements.
Absence of a pump controller	Some pumps are powered by DC and can therefore be powered directly by the panels without conversion. But the controller is sometimes forgotten or willingly not installed.	Excessive wear of equipment (mainly pump).
Power supply of the pump from an inverter designed for buildings, producing 220V – 50Hz	The pump can only run at maximum power. When there is not enough sun for the pump to run at maximum power, the pump will not start.	The system does not work in low luminosity (morning / evening / cloudy days). Loss of more than 50% of the pumping potential.
Use of batteries to ensure pumping by night or when luminosity is too low	Installation of an inverter designed to power buildings instead of pump systems (see above).	Unnecessary addition of equipment, expensive to renew, and pollutant at End-of-Life. If there is need for water beyond sunlight hours, store the water in a water tower.
Under sizing of solar array	The supplier is asked for a specific performance (a daily flow and a total head); he offers an adequate pump but an insufficient and unverified number of panels.	The pump runs at low speed, and the expected performance is not achieved.
Absence of electrical protection	Solar panels are seen as a non-hazardous power source because each panel produces 12 or 24V, a low voltage that is not dangerous in itself. Designers often omit electrical protections (fuses, circuit breakers, ...) But for solar pumping, the voltage of the panels is cumulative to be able to operate the pump. As a result, the voltage is often 120V to 500V, which is dangerous.	Risk of electrocution for users. Risk of destruction of equipment.
Absence of low-level water sensor	Some pumps are self-protected against vacuum operation: they are equipped with a sensor that stops them when the well is empty. But this is not the case for all pumps, and some pumps are installed without a sensor.	Destruction of the pump when the well is empty.

Most of these defects can be easily avoided, because they come from oversights due to lack of knowledge by the designer, or the opposite, due to too advanced technical specifications, causing suppliers to offer substandard and / or inappropriate hardware. The purpose of this guide is to find the right balance between too much details in quotation requests, and important oversights that can be made by unskilled designers.

***By no means this guide will allow the reader to become a solar pumping specialist**, other more complete (and more voluminous) guides are listed in Annex 1 at the end of this practical guide to improve your knowledge.*

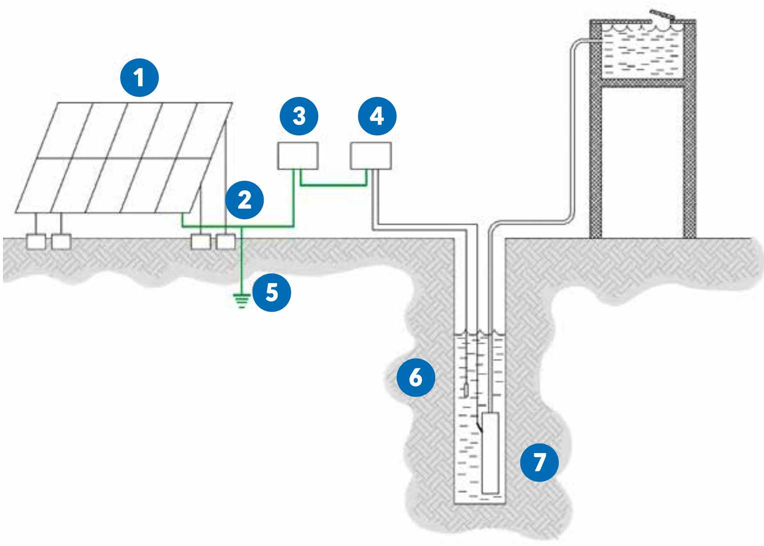
For any question, need for precise sizing, any particular case, contact:
***energyrequest@actioncontrelafaim.org** (for AAH staffs and missions only)*

2. MAIN COMPONENTS

Solar pumping systems have at least the components listed in Figure 2. They are detailed in the following chapters. These main components must be included in the Request for Quotation (RFQ) to ensure that the supplier understands the request correctly, and does not forget anything.

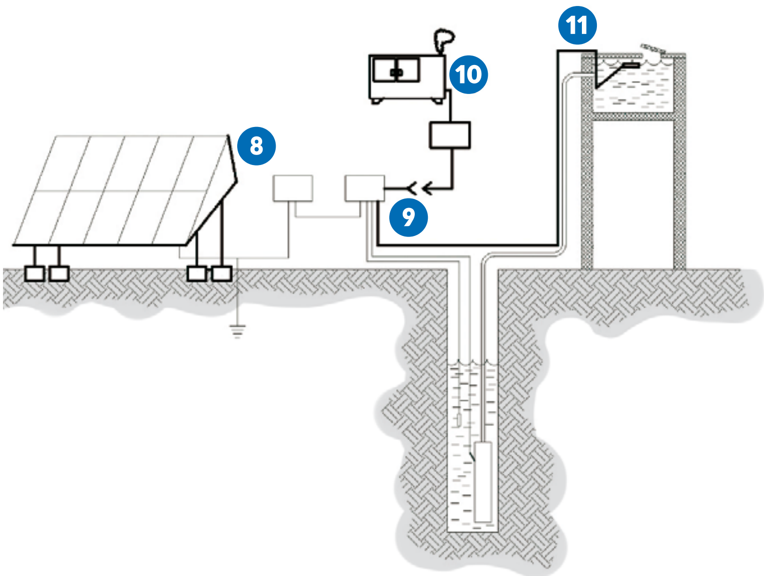
To this basic configuration can be added several options listed in Figure 3.

FIGURE 2: ESSENTIAL COMPONENTS



1. ***Solar panels.***
2. ***Panels stand** with concrete foundation and anti-theft system.*
3. ***Protection cabinet** with fuses, main contactor and surge protector device (lightning protection).*
4. ***Pump control box** or solar pumping inverter.*
5. ***Ground rod** connected to global ground circuit, including panels, stands, cabinets, controller and pump.*
6. ***Low level water sensor** (stops pump immediately if water level drops).*
7. ***Submersible pump.***

FIGURE 3: OPTIONAL COMPONENTS



8. ***Solar tracking stands (1 or 2 axis)** (summer / winter).*
9. ***Possible input for a backup power generator, to be used in case of defect of solar panels** (Generator is not permanently connected).*
10. ***Permanent power generator** for backup or complementary source (cloudy / rainy season or sunrise / sunset hours).*
11. ***Water level sensor** in the main tank for automatic start/stop of the pump,*
    *or **Water level sensor for automatic start/stop** of the pump, plus water level indication with **possibility of remote display.***

In most cases, it is not necessary to size each component. The recommended method is to indicate the expected performance (daily flow and total head) on the request for quotation, thus letting the suppliers choose how to size the installation, and to propose custom-fit equipment for the best price.

However, once the offers have been received, it is important to verify the sizing recommended by suppliers. For this, a calculation method is presented in *chapter B - Sizing and calculation.*

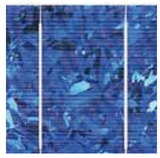
1 PHOTOVOLTAIC SOLAR PANELS (PV)

There are many types of solar panels and many denominations: monocrystalline, polycrystalline, Cadmium telluride (CdTe), CIGS, CIGSS, Amorphous Silicon (a-SI), ... All have advantages and disadvantages, different costs and performance ratios.

CdTe, CIGS, CIGSS, a-SI panels types are not recommended for solar pumping, for different reasons: they are difficult to replace (rare supply possibilities), they consume rare metals, present significant difficulties in terms of recycling, can generate long-term soil pollution if not recycled, ...

AAH programs should only use the two types of panels presented in Table 3 below.

TABLE 3: RECOMMENDED TYPES OF SOLAR PANELS

TYPES OF PANELS	MONOCRYSTALLINE (MONO-C)	POLYCRYSTALLINE (POLY-C)
Example image		
Aspect of the cell	Cells are generally dark blue and uniform	Cells are generally clear blue and crystals are visible
Performance ratio	13 to 17%	11 to 15%
Advantages	• Better performance ratio than PolyC in low light conditions • Longer life time than PolyC	• Cheaper than MonoC • Low carbon footprint • Low sensitivy to temperature fluctuations
Disadvantages	• Higher price than PolyC • Low performance with high temperature	• Lower performance than PolyC • Life time a little bit shorter than MonoC

These types of panels are very similar and can be installed interchangeably: polycrystalline is slightly cheaper than monocrystalline but has a lower performance. In order to deliver the same power a larger surface of polycrystalline must be installed; its lower cost is therefore not so beneficial anymore. The two solutions are almost equivalent in terms of performance and price, therefore their availability on the market is often a more important criterion than the performance ratio.

TECHNICAL SPECIFICATIONS OF QUOTATION REQUESTS

Labels on solar panels show a lot of information, mainly used to control the performance of panels over time and during maintenance operations. When purchasing solar panels and checking them upon delivery, only 5 specifications are used:

• PANEL TYPE	Specify «monocrystalline and polycrystalline are accepted».
• PEAK POWER	We do not specify power on the request for quotation (leaving the calculation of required power to the supplier), but we will verify upon delivery that the power of solar panels corresponds to the proposed power.
• CONNECTOR TYPE	Specify «MC4» which is the standard connector type.
• LIFE TIME	Specify a "product guarantee period of 10 years / performance guarantee period of 25 years at 80% of production".
• STANDARD	Specify «in accordance with standards EN 61730 and/or UL1703».

MC4 connector Male (up) and Female (down)

2 SOLAR PANELS STANDS

Solar array configurations are very different from one site to another (on the ground, on roof, on water tank, with optional solar tracking system – see 8, number and position of the panels ...). Therefore, stands of solar panels are tailored to each system and made by the supplier. On a quotation request, only indicate the following elements:

TECHNICAL SPECIFICATIONS OF QUOTATION REQUESTS

• ORIENTATION/TILT	Specify « south oriented » (or north depending on the hemisphere of installation), ideal tilt according to the latitude of the installation site.
• FIXING	Specify that the stand must be designed, and have sufficient anchorage, to withstand wind.
• PROTECTION AGAINST CORROSION	Specify that the stand must be protected from corrosion.
• FIXING THE PANELS ON THE SUPPORT	Specify that panels must be fixed to prevent any theft of the panels.
• EARTHING / GROUNDING SYSTEM	Specify that the panels and their stands must be grounded with the appropriate cable thickness (see chapter earthing/grounding system).

With these indications, the supplier can design and quote the stand. Table 4 below lists the design options available to suppliers, and can help you perform checks on the supplier's panel stand.

TABLE 4: POSSIBLE TECHNICAL SOLUTION FOR SUPPLIER TO RESPOND

FEATURE	TECHNICAL OPTIONS
Panel Tilt	The optimal tilt angle in common climates for best year-round performance is the latitude where the panels are installed. There are two exceptional environments where this angle is not optimal: • Areas with monsoon climate or long cloudy season, the optimal angle can be changed so that the panels are perpendicular to the sun's rays during monsoon or cloudy season. • Areas near the equator (the central band located between 10 ° North and 10 ° South: Sierra Leone, Liberia, CAR, DRC, South Sudan, Kenya, Somalia ....). In this area we would theoretically install panels horizontally, but the minimum installation angle is 10 ° to allow cleaning, avoid accumulation of dust, ... In the equatorial band, the solar array can be divided into 2: one half inclined 10 ° to the north, the other half inclined 10 ° to the south. Finally, it is always possible to request panel stands that can have two or three inclinations: • Tilt A = Optimal angle = latitude of the place of installation (out of equatorial band) • Tilt B = Tilt A - 12 ° • Tilt C = Tilt A + 12 °
Support foundation (fixing on the ground)	In addition to the weight of the panels, the support of the panels must also be able to withstand the uplift pressure on the panels due to wind blowing under the panels. A solid anchorage requires: • a solid/strong fixation on the frame without damaging the waterproofness for the roofs, • anchoring is done with concrete foundations 30x30 cm length and width, and at least 50 cm deep.
Protection against corrosion	The panel stand must be resistant to corrosion. For this, 3 methods are generally used: • the stand can be made of aluminium (expensive) • the stand can be made of galvanized steel. In this case, make sure that the welds are painted after finishing. • the stand can be made of steel. In this case ensure the support is covered with two layers of paint, one made with a rust-proof paint, the other made with a thick paint finish.
Panels fixing (on the support)	Fixing the panels on the support must prevent theft, making it as difficult as possible to remove them. For this, the following prevention measures are commonly used: • Place the panels at a height (on a roof, on the water tower if the surface allows it, ...) • Surround the park of panels with a wire fence (with barbed wire at the top of the fence if there's a major risk of theft). • Weld stirrups on the stand to block the panels. • Use anti-theft nuts if it is possible to supply them (split nuts or nuts with special head requiring a special key to unscrew), or use socket screws and plug the screw head with putty when the nuts are inaccessible. In case of welding very close to the panels, protect the panels before welding so they are not damaged.
Grounding/ Earthing	• The panels must be connected to the support with same size of wire than solar panel cables, and the support must be connected to the ground using a 16 mm^2 cable.

3 PROTECTION CABINET

The protection box is essential on all pumping sites where the operating voltage (at the pump) is higher than 120V. The installation of a cabinet concerns almost all pump systems as this voltage is reached even on small installations (4 panels of 250Wp).

The protection cabinet is used to:

- Protect equipment from overload (fuses)
- Switch off the installation to perform maintenance via a main switch ON / OFF
- Protect the installation from lightning strikes and surges (surge arresters - SPD)
- Create a central point of grounding
- On some high power pumping systems, it also used to connect the different strings of solar panels together, and accumulate their power in a single output that will power the controller or the inverter

FIGURE 4: DIAGRAM OF A EUROPEAN STYLE CABINET FOR 3 PANEL STRINGS

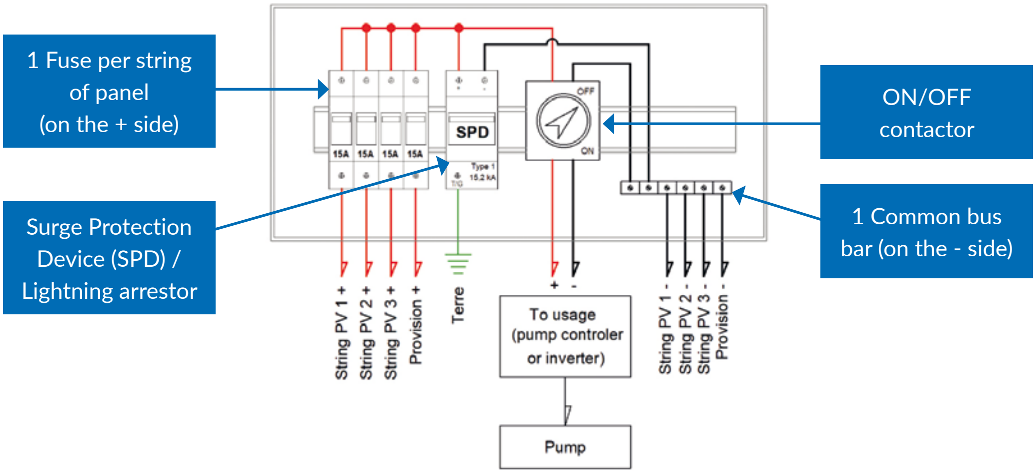
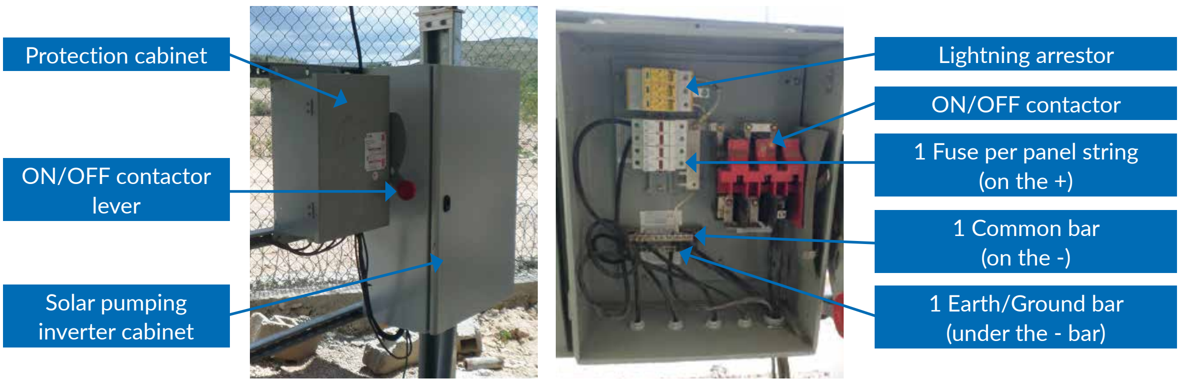


FIGURE 5: EXAMPLE OF A US STYLE CABINET *(same components than figure 4)*



External view *Internal view*

Protection cabinets are generally quite small and not expensive, but they are regularly forgotten. However, they ensure the durability of the installation (longevity of the equipment) and the safety of staff during maintenance operations.

4 PUMP CONTROLLER OR SOLAR PUMPING INVERTER

Except for specific cases, (for example when rehabilitating a borehole and you need to procure a controller for an existing pump), it is the supplier's responsibility to propose a suitable controller (or inverter) for the pump he selected for his offer. It is therefore rare to detail the technical specifications of a controller (or inverter) in a quotation request.

In a price schedule (BoQ), it is acceptable if the line «pump controller» or «solar pump inverter» appears, meaning that this equipment is to be provided, including the following functionalities:

TECHNICAL SPECIFICATIONS OF QUOTATION REQUESTS

- **MANUAL ON/OFF BUTTON** manually turn on and off the pump.
- **PROTECT FROM LOW WATER LEVELS** automatically stop the pump when there is no water above the pump.
- DISPLAY CURRENT RUNNING POWER OF THE PUMP check if the pump is running at full speed or is under charged, mainly in the morning and evening when there is a little sunlight.

The following functionalities are optional:

- Connection of a sensor system to start / stop the pump automatically depending on the level of water in the main tank.
- Alarm report on terminal block to report problems remotely, or to automatically turn on a generator in case of problem, or when the tank is empty due to lack of sunlight.

PUMP CONTROLLER OR SOLAR PUMP INVERTER?

These two devices have the same function: to operate the pump. The different name between controller and inverter comes essentially from the type of pump they drive:

- **Small pumps** (<2kW ou 3HP) are mainly powered by direct current (DC) and are driven by the voltage variation.
- **Medium and heavy pumps** (>4kW ou 5,5HP) are powered by alternating current (AC) and are controlled by frequency variation. To make this possible, the DC current of the panels must be alternated or inverted, hence the name «pump inverter».
- **For intermediate power** (between 2000W and 4000W), suppliers may offer DC pumps or AC pumps, or pumps that support both types of voltage, depending on the brand they usually supply, what they have in stock, ...

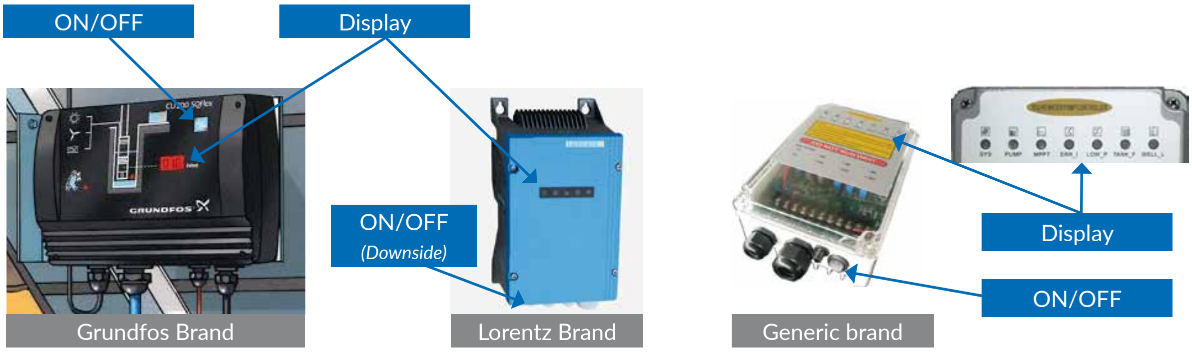
It is important not to specify a specific type of voltage so that the supplier can propose the type of pump (DC, AC or AC / DC) for which it will be the most competitive.

When we do not know the type of pump and its supply voltage, we use the generic term «pump controller» (or «pump control unit»).

PUMP CONTROLLERS

The rotation speed of the pump is controlled by its voltage supply: the higher the voltage, the higher the rotation speed of the pump. Pump controllers are small, have at least one ON / OFF button, a display showing the status of the pump, and faults encountered if they cause the pump to stop. Figure 6 displays 3 commonly used pump controllers.

FIGURE 6: THREE EXAMPLES OF PUMP CONTROLLERS



SOLAR PUMP INVERTERS

The rotation speed of the pump is controlled by the frequency (in Hertz) of the AC voltage. The solar inverter will therefore produce a variable frequency depending on the DC voltage it receives from the panels. Typically, a solar pump inverter will start the pump at a minimal frequency of 25Hz when there is little sunlight. It will increase the output frequency as sunlight and thus the DC voltage of panels increase, to finally reach a maximum frequency of 50Hz (or 60Hz depending the pump) at peak hours.

It is therefore impossible to use an inverter designed to power buildings, for a solar pump. Inverters for buildings are designed to deliver a fixed frequency of 50 or 60 Hertz (grids and generator frequencies). If you do it anyway, the pump will only run at the fixed frequency of 50Hz or 60Hz (its maximum power), and when the panel voltage is not sufficient to allow the inverter to produce 50Hz (morning, evening, cloudy days, ...) the pump will not run. Therefore, you will not reach the full potential of solar pumping, which main goal is to provide water even when there is little sun.

For most solar pump inverters it's possible (or even necessary) to set the minimum starting frequency ; the maximum frequency at full power ; the power of the pump ; the type of start-up ; the type of low water level probe ... Figure 7 presents the main solar pump inverters.

FIGURE 7: EXAMPLE OF SOLAR PUMPING INVERTERS

5 GROUNDING SYSTEM

All solar pump systems must be grounded via a ground rod. Equipment to connect to the ground network are:

EQUIPMENT TO BE GROUNDED	SIZE AND TYPE OF WIRE TO CONNECT TO THE GROUND ROD
Solar panels, usually a small hole is already made in the frame of the panel where the symbol earth (see above) is already present.	Same size as solar panels cables
Solar panel support / stand and metallic frames	16 mm² / Insulated or Bare Copper
Lightning arrestor inside the protection cabinet	16 mm² / Insulated
Metal frame of pump controller or inverter if in a metal frame	16 mm² / Insulated
Pump controller or solar pump inverter	Same size as power supply cables
Submersible pump	Same size as power supply cables

6 LOW LEVEL WATER SENSOR (IN THE BOREHOLE)

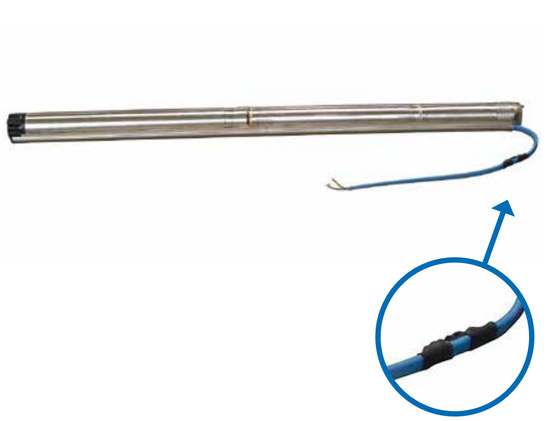
All pumps must be protected against lack of water. The lack of water occurs when the pumping rate is greater than the capacity of the well, for example in the dry season or in case the slots of the well screen are clogged.

In the large majority of cases a sensor provides protection against «lack of water», placed between 10 and 30 cm above the pump. Most of the time this is a separate probe (figure 8), which is fixed with stainless steel collars (cerflex) or plastic collars (colson) on the discharge pipe, or on the galvanized steel suspension cable of the pump when the discharge pipe is flexible. The probe should never be attached to the power cable, as this cable must always remain relaxed.

Some suppliers (such as Grundfos - only in the SQFlex range) integrate this probe directly into the pump supply cable (figure 9), but this is still rare. In any case, you must include this safety feature into your quotation request.

FIGURE 8: TYPICAL SENSOR AND ITS FIXING ON THE PIPE

FIGURE 9: GRUNDFOS PUMP - SQFLEX WITH LOW LEVEL SENSOR INTEGRATED ON THE CABLE



❼ SUBMERSIBLE PUMP (OR MOTOR-PUMP GROUP)

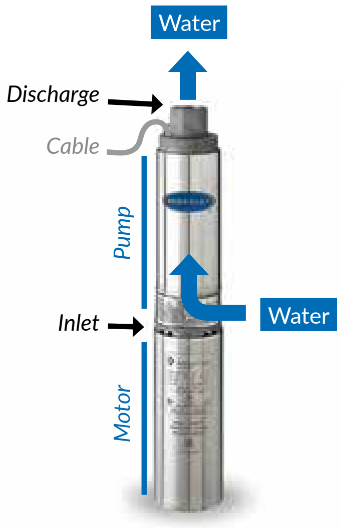
Whatever the type of pump (centrifugal, helical, volumetric, ...), submersible pumps still have the same main components shown in figure 10:

- The Motor (AC, DC, ou multi-voltage), always located in the lower part. The motor is always immersed, which is necessary for its cooling
- Suction orifice (inlet) equipped with a coarse strainer to filter large impurities in the water
- The Pump, always located at the top
- Discharge orifice (outlet) with screw thread to screw in the discharge pipe. The outlet is generally equipped with a check valve.
- A short length of cable (50 cm to 1 m) sealed in the motor so that the installer does not have to open the motor to connect the power cable (and potentially break its sealing)

It is not necessary to give technical specifications for the type of pump (AC or DC, centrifugal or volumetric, ...), leaving the choice to the supplier to propose the most adapted product for the best price. Only 2 parameters need to be specified on the request for quotations, because they have a strong influence on the life time of the pump:

- The constituent materials of the pump: all parts exposed to water must be in stainless steel of AISI304 minimum quality, in order to be naturally protected against corrosion
- Type of motor: for maximum durability, care should be taken to choose "brushless" motors, (note this name is also used in French-speaking countries). The rotor of these motors is fitted with permanent magnets rather than electromagnets requiring a supply by friction of brushes (coals), that are a source of breakdowns. Brushless motors therefore have better performance (no friction) and have no internal wearing parts.

FIGURE 10: STANDARD PUMP



In addition to requesting a pump in stainless steel AISI304 equipped with a brushless motor, it is also necessary to specify the quality of the water to be pumped in the quotation request. If sample analysis results are available, indicate the operating conditions:

- The water temperature
- The degree of impurity present in the water (Grain size)
- Any other parameter concerning the water to be pumped, which could influence the operation of the pump: pH if different from a neutral pH (7), the chemical composition if particular how/low values, ...

PUMP POWER CABLE EXTENSION

If the pump is correctly sized, made of stainless steel and equipped with a quality motor, then the weak point of the system will not be the pump but its installation. Indeed, the pump is delivered with a small cable (50cm to 1m maximum) that must be connected to the power cable that goes down into the borehole.

This connection must be perfectly sealed and durable in time. For this, the 3 approved systems are shown in Table 5 below.

TABLE 5: METHODS OF CABLE EXTENSION, QUALITATIVELY SORTED

	DESCRIPTION	PICTURE OF A KIT	KIT INSTALLED
BEST QUALITY Plastic junction box with liquid resin	This is a kit consisting of an envelope (housing) generally spindle-shaped, tightened at the ends to tighten the cables, and flared in the middle to leave the volume necessary for connectors in the central part. Once the connection is made and the box closed around the connection, the resin supplied with the kit is poured, then hardens and makes the assembly long-term waterproof.		
SECOND QUALITY Heat Shrink Solder Sleeves	It is a set of sleeves composed of 3 parts: • Crimp sleeve to connect the conductors to each other • Heat-shrinkable sleeves to put on wires • Heat-shrinkable sheath to put on the entire cable Warning: the installation of this kit requires some specific skills to be really waterproof.		
APPROVED **BUT TO AVOID IF POSSIBLE** Cable extender	It is a waterproof kit to screw. It is not recommended because: • Once the connection is made, there is still air in the connection part. This system is not resistant to pressurization and is generally not waterproof above 5bar (50m deep). • It does not fit on flat cables, but most pumps are equipped with flat cables.		

All systems done with tape (electric or standard), connector blocks, WAGO, ... with or without “waterproof box” ARE PROHIBITED. These systems (main ones of which are presented in figure 11) are not resistant to pressure, do not last long, and / or do not provide a real sealing. These boxes are called «waterproof» because they are rainproof, but they are not submersible at all.

FIGURE 11: MAIN PROHIBITED SYSTEMS FOR SUBMERSIBLE EXTENSIONS

3. OPTIONAL COMPONENTS

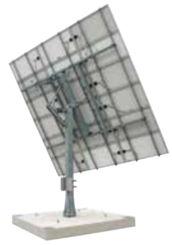
8 SOLAR TRACKING SYSTEMS (MANUAL OR AUTOMATIC)

Photovoltaic solar panels perform best when the collecting surface is oriented perpendicularly to the sun's rays. If panels are fixed, with the ideal orientation and the ideal tilt angle, then the panels will only catch the sunlight perpendicularly for a very short time: between 12Noon and 2PM, in spring (March) and autumn (September).

Outside this window (time of the day and year), the sun's rays will not be perpendicular to the panel's surface, and solar panels will produce less than their potential output. To maximize the panel's performance, it is possible to install panel supports with the ability to change their orientation and / or their tilt depending on the season and time of day. This can be done manually or automatically.

Fully automated systems (see picture beside) are commonly called solar tracking systems in all countries (including French speaking). They are not recommended for rural and remote site installations because the risk of failure and limited repair options can have an important impact. On the other hand, we should not ignore the possible gains that can be made by installing a simple system, i.e. by changing the orientation and / or the tilt of the panels manually.

Manual modification systems of the horizontal axis according to the season (figure 12) generally increases the yield by + 15% per year compared to a fixed support. Manual modification with vertical or inclined axis (figure 13) allows for a 25% gain in efficiency compared to fixed supports. These last systems have a great potential but require having an operator permanently on-site to modify panels orientation according to the time of day.



Rear view of "solar tracking system" Full automatic system (dual-axis).

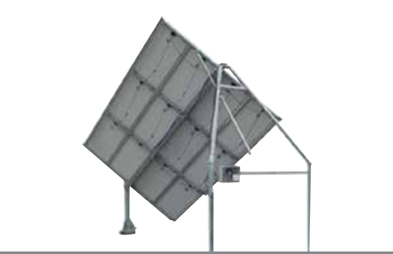
FIGURE 12: HORIZONTAL AXIS MODIFICATION - MAIN SYSTEMS (following the season)

Central axis
Locking/Moving system at the rotation axis

Central axis
Locking system backside of the panel

Tilt modification by changing legs length

FIGURE 13: VERTICAL AXIS MODIFICATION – MAIN SYSTEMS (following hours)



Tilted axis for important latitudes (> 40°)

Vertical central axis – self standing (small group of panels)

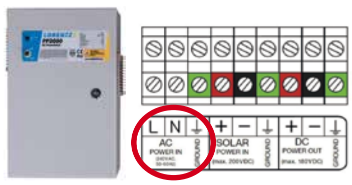
Offset axis with support on circular concrete strip

9 10 POWER GENERATORS – BACKUP OR SEASONAL SUPPLEMENT

Solar pumping is generally designed to be fully autonomous, however, as soon as the water supply is critical for agriculture or vital for the population, it is essential to provide a connection for an external energy source, usually a generator.

This external energy source can be used either in case solar power is unavailable (breakdown, troubleshooting, or maintenance), or in addition to solar during certain seasons or weather events: heavy rain, cloud cover, snow covering the panels... This energy source may not be permanently connected but the possibility of connecting it must be provided. There are currently 3 different generator connection options shown in table 6 below.

TABLE 6: POWER GENERATOR POSSIBLE CONNECTIONS

With a special cabinet to be ordered from the pump supplier, that converts the source (changeover solar to generator)	Through an input provided for this purpose inside the pump controller or the solar pump inverter	With a pending MCB (motor type) in a box. The box is itself connected to the input provided for this purpose inside the pump controller or the solar inverter
 (Example - IO101 cabinet Grundfos brand)	 (Example PP2200 Power pack Lorentz brand)	 This system is installed when the generator is located far away from the inverter. In this case we install a kind of permanent extension that ends on a box on which we will connect the temporary or permanent generator.

Under no circumstances you may install an extension cord terminating with a male plug, permanently connected to the installation, and ready to connect to a generator. The connection to a generator must be made by an isolated terminal block (or motor MCB) provided for this purpose.

You can never connect a generator directly to the pump, even via a changeover, because by doing so, all safety features become nonfunctional, particularly the low level water sensor in the borehole.

If there is no need for a generator permanently connected to the pumping system, then we will avoid installing one altogether. Installing a permanent generator when not necessary can be seen as a bonus or an extra for the beneficiaries, but it is not.

The installation of a permanent generator requires fuel storage, oil, spare parts, regular start-ups for maintenance, drained oil treatment or dumping ... and therefore a significant additional cost for the beneficiary community.

The sizing rules of backup or complementary generator sets are identical (see calculation chapter). The generator output voltage must be compatible with the power supply of the pump controller or pump inverter.

Standard specifications for generator installation should also be applied to generators installed for pumping sites (slab thickness, clearance around the machine, cooling air flow, fire extinguisher ...).

⑪ WATER LEVEL DETECTION IN THE TANK

Water level detection can be useful to:

- Automatically start and stop the water pump when water level is low in the tank and when tank is full (avoid overflowing and water loss).
- Run alarms (lights, sound alarms, indicators ...).
- Know the level of water in the tank when the tank is hardly accessible due to its height, or when the tank is located far away from the borehole or distribution point.

To perform these functions, two main categories of sensors can be used:

- « Free-volt contact » sensors. These sensors will work as a switch, will open or close when a certain level is reached. It is not possible to accurately measure the level with this type of probe and display it in m3. They are only used to send punctual signals, typically «pump start», «empty tank», «pump stop», ...
- Potentiometric probes, commonly called « 4/20 milliamps » for the current value they allow: 4 mA of current for minimum value (tank empty) and 20 mA for maximum value (tank full). These sensors can measure the level of water with 1cm of precision, send this information to an electronic calculator, that will convert the signal in m3 and display it on a screen. In addition, these calculators can also switch on or off some pre-programmed « free-volt contact », as explained above.

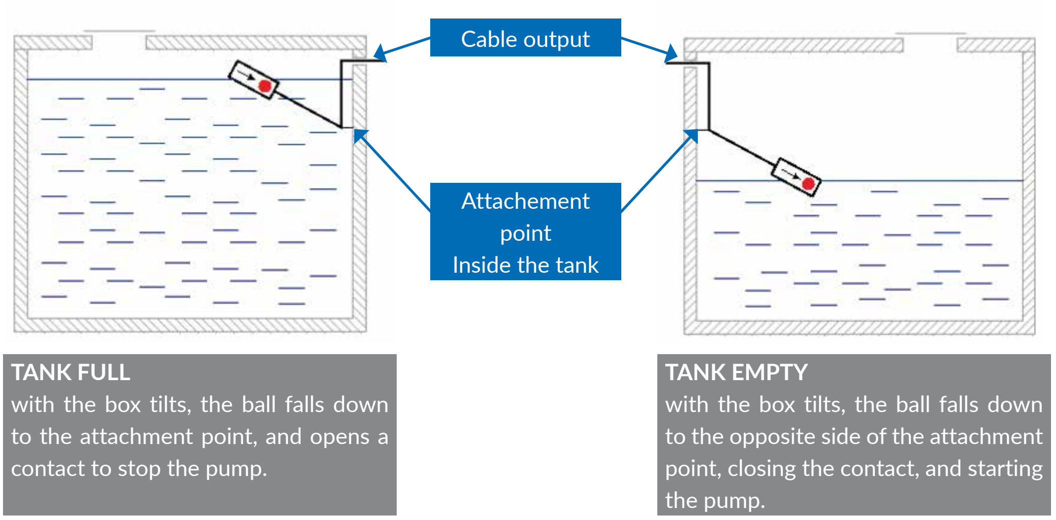
FREE-VOLT CONTACT SENSORS

Floating sensors

The type of probe most commonly used if you only want it to turn the pump on/off, is the «floating sensor». The sensor consists of a sealed plastic box filled with air (which floats). Inside this box is a ball, that activates a start / stop contact as the box tilts (see figure 15 below).

FIGURE 14: IMAGE OF STANDARD FLOATING SENSOR

FIGURE 15: OPERATION OF A FLOATING SENSOR



This type of probe is very practical and easy to install; however, it is not very reliable over time: the ball tends to become jammed after some time. If a high reliability and / or durability is required, it is possible to perform the automatic start with «electrode probes» presented below.

Electrode probes

To trigger actions, it is also possible to use electrode probes. This detection is done with a set of stainless-steel electrodes suspended at different heights in the tank. These electrodes are connected to a relay placed in the cabinet, which interprets the measurement and sends the signals of start, stop...

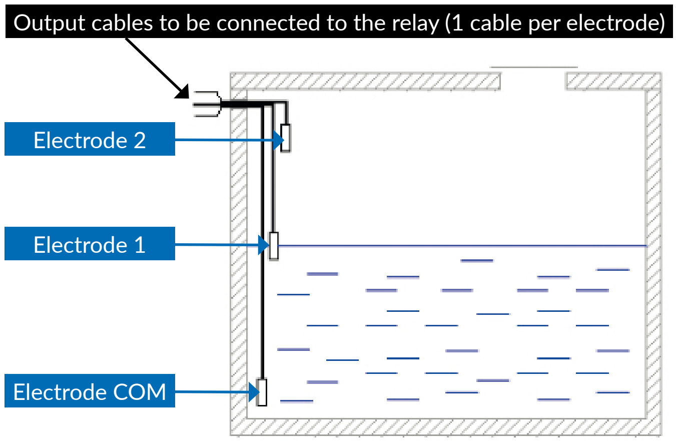
We commonly use 3 electrodes for a basic start / stop automatic system:

- The first electrode is placed at the lowest possible level inside the tank, and is used as a reference level. This low-level electrode is generally called "COM" on diagrams.
- Other electrodes are suspended at levels where a level detection is warranted.

FIGURE 16: RELAY *(LEFT SIDE)* AND ELECTRODES TO BE SUSPENDED TO WIRE *(RIGHT SIDE)*

On Figure 17 below, the COM electrode is installed at the bottom of the tank. When the tank is full, the water makes contact between the COM electrode and the electrode 2. The relay interprets this contact as a «tank full» signal and stops the pump.

FIGURE 17: OPERATION OF AN ELECTRODE PROBES SYSTEM



When water level goes below electrode n°1, there is no contact between COM and any other electrodes.

The relay understands that the tank is getting empty, and starts the pump.

Then the water level increases in the tank, until water touches the electrode n°2. This makes contact between COM and electrode n°2, the relay understands that the tank is full and stops the pump.

It is possible to face electrode probes because some pump controllers use this type of probe as standard. They are much more reliable over time than floating sensors. When installing them, make sure to attach them to a support because the electrodes are suspended from cables, and will be subject to the swirl of water into the tank created during refills. They must be fixed to a weighted cable or placed in a HDPE tube which is itself fixed to a wall, so they do not start to spin with the tank water filling.

POTENTIOMETRIC PROBES (OR « 4/20 MA »)

Magnetic float sensors

This type of sensor is especially used on metal and plastic tanks because they are screwed onto the tank. It is very rare to see them on concrete tanks unless you have made a metal plate with screw connections.

A float with magnetic ring inside will slide along a rigid rod (See figure 18 for illustration). Depending on the position of the float on the rod, the current that the probe passes will vary between 4 mA (minimum level) and 20 mA (maximum level). This current is then interpreted by a remote display (see the displays below). This type of probe is very reliable and can display a level with 1 cm of precision.

FIGURE 18: TYPICAL MAGNETIC FLOAT SENSOR

Pressure transmitting probes

The probe (see figure 19) is placed in the lower part of the tank and measures the water level (accuracy is 1 cm) according to the pressure it undergoes: the higher the water level above the probe will be, the more pressure there will be. The probe transmits the same information as the sliding float probe (fluctuation of the output current), and can be interpreted by the same type of display.

Like electrode probes, pressure-transmitting probes are suspended in the tank. If it is not fixed, it will «swirl» during refills and this will damage the cable at the point of attachment. It must therefore be attached to a support: a suspended stainless steel cable with a weight, or a vertical bar fixed in the tank.

FIGURE 19: TYPICAL PRESSURE-TRANSMITTING PROBEE

Mind: minimum and maximum height of water must be specified when ordering the probe to the supplier, in order to ensure the minimum current (4 mA) at minimum level, and maximum current (20 mA) at maximum level of water (Manufacturer settings).

DISPLAYS FOR POTENTIOMETRIC PROBES

Potentiometric probes (or «4/20 mA») are to be connected to display units provided for this purpose. These displays are generally compact (see figure 20), and they necessitate a setup, especially to know the shape of the tank (cubic, horizontal cylinder, vertical cylinder, or other). A display has at least the following functions:

- Ensure the power supply of the probe (12 or 24V DC to be specified to supplier)
- Calculate the quantity of water in the tank in m3 depending on the water pressure, and the set tank shape and size.
- Send some signals (free-volt contacts) based on defined thresholds

FIGURE 20: TYPICAL DISPLAYS

Hitec Brand

Afriso / Eurojauge Brand

Interjauge Brand

Potentiometric probes have many advantages: high reliability over time, accurate measurement of the level and display in m^3, option of automatic start / stop, remote reporting of alarms... they nevertheless have a major disadvantage: they must be electrically powered.

It usually consists of a small solar panel of 50W dedicated to the probe, and a small box with a charger and two batteries of 7Ah (size of a motorcycle battery or a UPS for desktop) to ensure a continuous power supply, no reset of settings. The display is generally attached to the front of the cabinet.

This power supply is not complex to implement, however there is no standard cabinet to perform this function. The box must be custom-made by the supplier.

B/

SIZING, INSTALLATION COMMISSIONING AND USER TRAINING


ACTIO
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As explained in the introduction and in the «main components» chapter, this document is not meant as a solar energy technical training. The recommended method is to specify to the suppliers the expected results - mainly the daily flow, and the total head - and to let suppliers propose the ideal sizing as well as the best suited equipment.

However, it may happen that suppliers come up with very different results as to the number of solar panels and the power of the pump to install. The calculation below only shows a sizing method to verify supplier offers. The check is done in several steps presented below.

1. SIZING

STEP 1 ELECTRICAL ENERGY NEEDS PER DAY

The goal of solar pumping projects is to lift a certain amount of water at a certain height, every day. This requires a quantity of mechanical energy (E2). To calculate the electrical energy to be supplied to the motor pump (E1), it is necessary to take into account the pumps performance, which varies according to each type of pump. If the efficiency of the pump is unknown, the following reference values will be used:

TYPE OF PUMP	VOLUMETRIC	CENTRIFUGAL (< 2 HP)	CENTRIFUGAL (> 2 HP)
Performance ratio	0,6	0,4	0,6

Formula for calculating the daily electrical energy in Watt hours per day (Wh/day):

$$\text{Daily Electrical Energy (E1)} = \frac{\text{Water Volume (m}^3\text{/day)} \times \text{TH (m)} \times 2{,}725}{\text{Pump performance ratio}}$$

EXAMPLE

To fill a tank of 30 m3 disposed at 10 m of height, with a 3 HP water pump, located in a borehole of 50m depth. Pressure loss in the pipe is estimated to 1 bar (voluntary overestimation).

$$\text{Daily Electrical Energy (E1)} = \frac{30\ (\text{m}^3\text{/day}) \times (10\ \text{m} + 50\ \text{m} + 10\ \text{m}) \times 2{,}725}{0{,}6} = 9\ 536\ \text{Wh/day}$$

In this example, the solar system will have to produce 9 536 Watt.hour (Wh) per day to power the water pump.

STEP 2 CALCULATION OF PUMP RATED POWER

Generally speaking, the rated water flow of the installed pump is equal to 20% (1/5th) of the daily energy need. We can calculate the pump power with the following formula:

$$\text{Rated Power of the pump (P1)} = \frac{\text{Daily Electrical Energy E1 (Wh/day)}}{5}$$

EXAMPLE

To equip the borehole from previous example (step 1), the rated power of the pump will be:

$$\text{Rated Power of the pump (P1)} = \frac{9\ 536\ \text{Wh}}{5} = 1\ 907\ \text{W}$$

STEP 3 CALCULATION OF DIESEL GENERATOR POWER

When powered by a variable energy source, such as solar panels that produce more or less depending on sun power, pump start-ups are progressive. This is not the case when pumps are powered by a generator.

After the generator starts, when the output circuit breaker of the genset is switched on, the pump is powered suddenly and reaches its full power in some milliseconds. This sudden increase of power of the electric motor generates strong magnetic fields, which the generator must overcome before the electric motor can start. This phenomenon is called a «load impact at start-up».

If you choose a generator with the same power as the pump (eg 2.2 kVA for a 2kW pump), it will be unable to start the pump. Concretely the engine of the generator set will stall brutally.

To avoid it, we apply the following calculation formula:

Generator rated power (also called LTP) (VA) = Rated power of the pump (W) x 3

EXAMPLE

To power the pump of 1 907 W previously calculated, we will require a generator of:

Generator rated power = 1 907 W × 3 = 5 721 VA so around 6 kVA

STEP 4 SOLAR PANEL POWER TO BE INSTALLED

To produce power, we want to install solar panels. The production of these panels depends on the amount of solar power received at ground level, and on their installation mode (see «solar tracking» option), a loss of efficiency due to maintenance (dust film) and the aging of the panels over time. The photovoltaic performances regularly observed are as follows:

TABLE OF PERFORMANCE RATIO to select, depending on type of installation and operating conditions	**Fixed installation of solar panels**	**Horizontal axis tracking** (tilt modification to be adjusted with seasons)	**Vertical axis tracking** (orientation modification to be adjusted with the hour of the day)	**Full automated modification on 2 axis**
Performance ratio in dusty environment or lack of maintenance (panel cleaning)	0,5	0,6	0,7	0,8
Performance ratio in clean environment with good maintenance level (regular cleaning)	0,6	0,7	0,8	0,9

Formula to calculate total required power of solar panels:

$$\text{Total peak power of solar panels (Wp)} = \frac{\text{Daily Electrical Energy E1 (Wh/day)}}{\text{Daily Irradiance (kWh/m}^2\text{/day) x Performance ratio}}$$

Note: *The daily irradiance is to be read on a map of sunshine as presented in annex 2. These maps are year averages, so we must be very attentive to the seasons, including rainy seasons and monsoons. During these seasons, the sun power on the ground can decrease by 50% compared to the average value on the map.*

EXAMPLE

To produce energy to the system previously calculated, located in north of Nigeria and receiving 6 kWh/m²/day (see map in annex 2), with solar panel fixed (no tracking system) and in the desert (dusty environment):

$$\text{Solar panel power} = \frac{9\ 536\ \text{Wh/day}}{6\ \text{kWh/m}^2\text{/day} \times 0{,}6} = 2\ 648\ \text{Wp}$$

To produce power to this borehole, it will be necessary to install 2 648 Wp of solar panel, on fixed stands. Depending on the power of panels available in supplier stock, we can use:

11 panels of 250 Wc each (11 x 250 Wp = 2 750 Wp)
Or
9 panels of 300 Wc each (9 x 300 Wp = 2 700 Wp)
Or
8 panels of 330 Wc each (8 x 330 Wp = 2 640 Wp)

This calculation is a global approach. The real total number and the unit power of the panels also vary depending on the voltage necessary for the operation of the pump, the panel's technology, ... however the total power supplied (number of panels multiplied by unit power) cannot be lower than the power calculated above. If the real installed power is less than the calculated power, then the installation will work, but will not provide the requested amount of water. This undersizing is to be detected when measuring water flow, during commissioning (see chapter dedicated to commissioning).

STEP 5 CONCLUSION OF THE CALCULATION

EXAMPLE

For this example, on the request for quotation (RFQ) we will only specify the daily water flow (30 m³/day) and the total head (70m), with the list of main components + options. Suppliers should respond with offers approximately corresponding to following equipment:

- A solar submersible pump, Stainless steel AISI304, Brushless motor, rated power 1 900 W + adapted controller
- A backup power generator of 6 kVA if any, or a cabinet end line with capacity to connect a 6 kVA generator in case of need.
- A solar panel power of 2,6 kWp disposed on fixed stand, including a set of 8 to 11 panels depending on their power (8 panels of 330Wc to 11 panels of 250Wc).

It can be seen from performance tables that decreasing coefficient can be up to 30% larger than this calculation (if pump with a lower efficiency for example), but can not under any circumstances be less than this calculation.

This method is therefore reliable for verification purposes. Regarding the detailed design, it is necessary to know the type of pump, its performance, its maximum and minimum operating voltages ... something that is generally not known at the stage of the quote request. We will leave it to the supplier to carry out the calculation, and engage his responsibility on it.

If you are in a context where the suppliers are not able to define the necessary equipment from the requested quantity of water and the total head, or if this calculation method brings results very different from technical proposals of suppliers:

> Send an email to: energyrequest@actioncontrelafaim.org
(for AAH staffs and missions only)

2. INSTALLATION COMMISSIONING

All too often, the reception of the pumping system is limited to a visual check of the water supply in the tank, and a small training to show the ON / OFF button to user committees. These checks do not ensure the proper operation of the system, so that that the desired quantity of water is actually supplied.

In addition, these «hasty» verifications lead to significant periods of dysfunctionality of the pumping sites, because in case of problems, communities that have not been trained are unable to identify the problem and to describe it, to quickly order spare parts, and thus to trigger the repair.

Below are the tests that must be performed to properly receive the installation, and the essential points of a solar pumping training.

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Tarpaulin test for partial covering to verify that the pump adapts its power depending on sun power.

Once the installation is completed, we have one more pitfall to avoid: check that the expected results are actually achieved. For this, 4 controls must be carried out:

1. **Perfom a visual check to verify that all requested equipments are actually installed,** and that they are functional. We will visually check that:
   - The grounding network is visible, and power cables are clean, with no strips or damages,
   - The protection cabinet is installed, and in a general way, equipments are well attached,
   - Tilt of panels is correct, as well as orientation of solar panels,
   - No leakage (weldings, elbows, valves, filters, ...) is observed near electrical items. By the way report leakages if any.
   - No water hammer noise (like « clac ») is made by water pipes when starting / stopping the pump. If any, the water hammer will, with time, damage weldings, seals, gluings ...

Test the ON / OFF button to verify the good functionality of the pumping system.

2. **If the low level probe in the well is present (and not integrated with the pump),** the low-level sensor must be disconnected at the controller level to stop the pump. By unplugging the probe, you simulate the lack of water in the borehole, the controller must interpret this as the fact that the pump runs without water and must stop it immediately.
3. **Check that the pump is working well at a variable speed.** For this purpose, a blanket or a tarpaulin is to be brought on the day of the pumping commissioning. Partially cover some solar panels (around 20%), and simulate a drop in light intensity: the speed of rotation of the pump should go down (but not completely stop). When removing the blanket from panels, the pump should return to its rated speed..

4. **Finally, it is necessary to control the pump output flow.** For this, use a clock (watch or phone) and a piezometric meter winder (or «dipmeter»). The goal is to make sure that the time needed to fill the tank is acceptable. This can be done:
   - By passing once in the morning and once in the evening to check that the tank has filled up during the day.
   - Or if the available time is limited, by controlling the water level in the tank after a certain time:
     - Measure the water level before starting the test and check the time.
     - Start the pump and wait for the water level to increase by at least 0,5 m, 1 meter ideally.
     - Stop the pump, check the time, and measure the height of water in the tank.
     - By calculation (tank surface x height) you will find the quantity of added water, and finally the water flow to ensure that expected result is delivered.

Once these 4 tests are done, you are guaranteed to get a functional solar pumping for many years. To ensure that you complete all the tests, a commissioning form is presented in the annex of this document.

3. USER TRAINING

User training is at least as important as the quality of your pumping system. Apart from the strict aspect of «handing over the installation to the community», the training allows users to fully understand how pumping works, to detect malfunctions, and to be able to make the first diagnosis in case of problem. Elements that constitute correct training to users are:

1. **For each pump system, a folder should be submitted to the management committee.** This folder must contain:
   - A descriptive sheet of the pump system, containing the essential elements: see annex 3.
   - User manual of installed equipment (pump, controller ...)
   - References of spare parts (mainly fuses, SPD cartridges ...) and where to buy them.
   - List of maintenance operations to be carried out (solar panels cleaning, opening and cleaning of inverters, of cabinet in dusty environment, verify that equipment do not heat, maintenance of generator if any ...)
   - Contact person and company that did install equipment.
2. **Presentation of equipment and normal operation,** so that users can detect the difference between a normal and abnormal situation.
3. **Pumping tests:** For each training, the pump must be started and stopped. These tests are to be carried out by the users and not by the demonstrator. When a tank level sensor is present, explain the operation of the sensor, the level displayed, ...
4. **If automatic start-ups are available (pump start, generator start, ...) explain what starts automatically and on which signal.** Inform users that self-starting equipment must be shut down during maintenance work.
5. **Simulation of a failure:** As the last element of the training, simulate malfunctions of the installation. The main simulated malfunction tests are:
   - Remove a fuse that prevents the system from starting up or that will lead the system to operate at a power much below its actual capacity if there are multiple panel branches.
   - Unplug a panel which also prevents the system from starting.
   - Disconnect the «low water level» probe if accessible and not integrated to the pump. This should normally prevent the pump from starting to prevent it from running without water.

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*Fault simulation exercise:
For each simulation, users must be able to correctly identify and repair the fault created. The trainer takes care to stay in the background during the exercise.*

ANNEXES

ANNEX 01
INFORMATION RESOURCES

You can find documents listed below on the intranet NHF, with the path:
French HQ > Logistics IS Department > Thematic Priorities > Energy

- Present document in PDF format, to print, re-print, and distribute to your team.
- The quotation request form, in XLS format
- The commissioning form (checklist), in DOC format
- Electrical safety guidelines for AC installation in building, if your site use it.

To deepen your knowledge of solar pumping, various resources are at your disposal, including:

- The solar guideline of "Practica foundation" for technicians and designers.
- The internet website of the Global Wash Cluster *(https://washcluster.net/gwc-resources)* with toolbox
- The internet website energypedia.info that have an important documentary resource related to various usages, including solar pumping but also solar cooking, drying, lighting, irrigation, …
- The Toolbox on Solar Powered Irrigation Systems (SPIS), mainly developed by GIZ and sustained by various donors. This toolbox box is very complete and include all the methodology for irrigation projects, calculation tools, partical guidelines, maintenance books, …

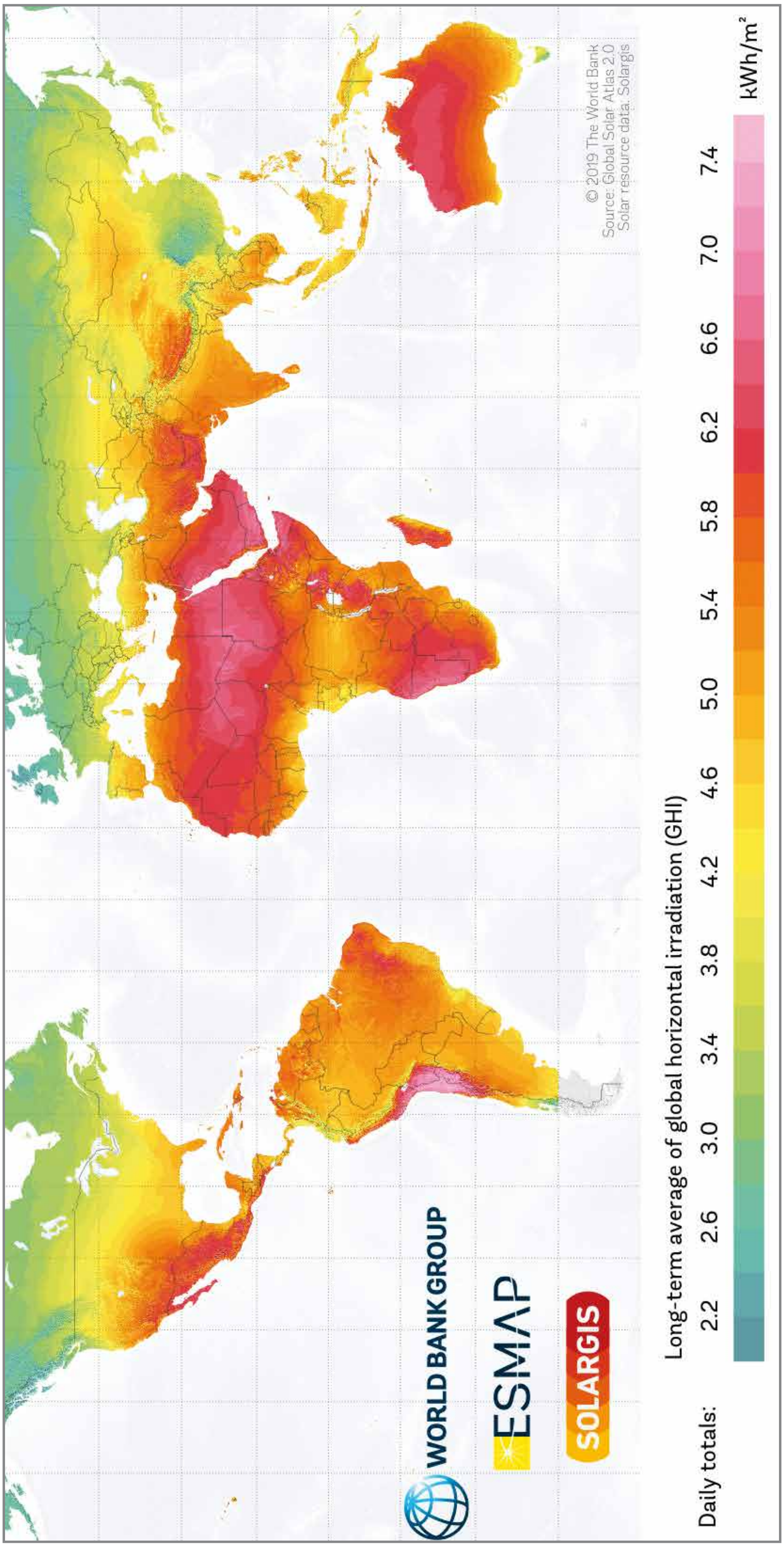
Estimates of sunrays are available from:

- The international database of SolarGis, which offer a lot of free maps, all downloadable at this address: *https://solargis.com/maps-and-gis-data/overview.*

Please pay attention to choose maps of GHI rays (Global Horizontal Irradiance).

- The international sun database of European Commission, available at this address:
  https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html
  Be careful, this database is very complete, sometimes it is more reliable to make a simple calculation with verified data and coefficient, than to make a complex calculation with data you are not sure of.

ANNEX 02
SUN'S RAYS MAP (GLOBAL HORIZ. IRRADIANCE)



ANNEX 03
PUMPING IDENTIFICATION SHEET

To be downloaded from the intranet NHF:
https://actioncontrelafaim.sharepoint.com/:f:/r/csw/lsi/Thematics%20Priorities/Energy/EN%20-%20A4%20-%20Solar%20pumping?csf=1&web=1&e=Kd6zD5

Or request by email to ***energyrequest@actioncontrelafaim.org***

SOLAR PUMPING IDENTIFICATION SHEET

Action Against Hunger
energyrequest@actioncontrelafaim.org

1 - General information

Installation site (location)		Name of installer	
Installation Date		Contact person & phone	

2 - Birehole specifications

Diameter	inch	Total static head	meter
Total depth	meter	Dynamic level	meter
Tube length	meter	Dewatering	meter
Strainer diameter	inch		

3 - Pump specifications

Pump brand		Motor power	HP / CV
Pump model		Discharge diameter	inch
Serial number		Maximum flow	m3/h
Water flow measured during comm.	m3/h	Maximum total head *(HMT)*	meter

4 - Pump controller or inverter

Brand		Max power	Watts
Model		Max admissible voltage (PV)	volts
Serial number		Max voltage output to pump	volts

5 - Solar panels

Brand		Total power installed	Watt-crête (Wc)
Model		Minimum voltage for pump start	volts
Number of solar panels		Max voltage of system assembly	volts
Unit power of each solar panel	Watt-peak (Wp)		

6- Tank

Material	
Capacity	m3
Tank filling time	

7- Remarks and comments

ANNEX 04
CHECKLIST FOR COMMISSIONING

To be downloaded from the intranet NHF:

https://actioncontrelafaim.sharepoint.com/:f:/r/csw/lsi/Thematics%20Priorities/Energy/EN%20-%20A4%20-%20Solar%20pumping?csf=1&web=1&e=Kd6zD5

Or request by email to ***energyrequest@actioncontrelafaim.org***

COMMISSIONING CHECKLIST

Action Against Hunger

energyrequest@actioncontrelafaim.org

Check the case when control is done. Please note your remarks on the commissionning sheet.

1 - Solar panels

- ☐ Note brand & references of solar panels on the identification seet
- ☐ Count number of solar panels
- ☐ Control orientation (south ou north following site of installation)
- ☐ Measure tilt of solar panels
- ☐ Measure the height from the ground (minimum 1 m)
- ☐ Verify state of solar panels, note number of damages panels if any
- ☐ Covering some solar panel with a blanket or a tarpaulin varies the pump speed rotation

2 - Electric wiring

- ☐ Verify type and section of cable
- ☐ Verify cable tightening in cabinet and at terminal connections
- ☐ Presence of cable glands at cabinet entrance
- ☐ Minimum height from the ground of 0,5 m for any cabinet
- ☐ Cable cerrectly fixed and attached
- ☐ Underground cables are installed inside ducts
- ☐ Cables between structure (panels groups) are undergrounded if any
- ☐ The solar panel support is connected to the ground with a cable of 16 mm^2 at least
- ☐ Solar panels are connected to their support with cables of 2,5 mm^2 cable at least
- ☐ Pump and its controller are connected to the ground by a cable of same size than power cables

3 - Solar panel support

- ☐ Support is made of a non-corrodible material (aluminium, galva.steel, ou steel with double layer of paint, including one anti-rust layer)
- ☐ Verify support alignment
- ☐ Verify verticality of poles
- ☐ Verify the good sizing and robustness of foundations

4 - Protection cabinet

- ☐ The protection cabinet is correctly installed (under shaddow, at more than 50cm from the ground, et correctly fixed)
- ☐ The cabinet have fuses (at least one fuse per panel string)
- ☐ The cabine is fitted with a lightning arrestor connected to ground by a cable of 16 mm^2 at least

5 - Fence

- ☐ Height of poles : 2 m
- ☐ Interval between poles : 2 m
- ☐ The entrance door close correctly
- ☐ Poles are strongly fixed

6 - Pump controller or inverter

- ☐ Note brand and model on the identification sheet
- ☐ Verify connection
- ☐ Verify height from the ground (mini 50 cm)
- ☐ Disposed under shaddow

7 - Pump

- ☐ Note rand and model on identification sheet
- ☐ Verify depth of immersion
- ☐ Cable is not tense (reserve for pipe elongation)
- ☐ Note length of borehole pipe
- ☐ Note length of cable

8 - Borehole head

- ☐ Check global arrangement
- ☐ Check valve in openned position
- ☐ Position vavle in open position
- ☐ Verify water meter

9 - Note here any additional control performed if any (low level water sensor test, level sensor in main tank ...)

NOTES

FOR FOOD.
FOR WATER.
FOR HEALTH.
FOR NUTRITION.
FOR KNOWLEDGE.
FOR KIDS.
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ACTION AGAINST HUNGER

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