Humanitarian Aid and Civil Protection

NRC NORWEGIAN REFUGEE COUNCIL

OXFAM

International Organization for Migration (IOM)

The UN Migration Agency

GLOBAL SOLAR & Water Initiative

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Preface

Solar photovoltaic [PV] pumping has in the last years undergone a series of technical and price developments resulting in advanced, robust, affordable, climate smart, versatile, low maintenance equipment. Favorable policies from an increasing number of governments and donors have opened an opportunity for organizations to scale-up and mainstream the use of solar PV pumping in their water supply projects. Solar PV Pumping is now cost-competitive with diesel powered water schemes in all sizes.

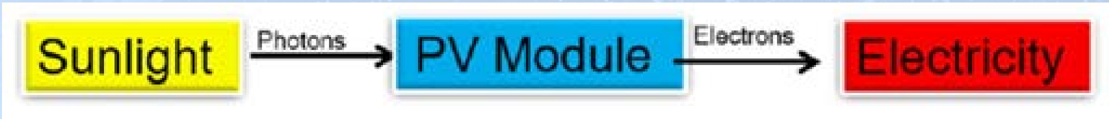
Relief organizations have been however slow in adopting and benefiting from the advantages that solar PV pumping solutions brings nowadays, still relying largely in diesel generator powered pumps. Lack of technical expertise and awareness has been identified as the single most important barrier to scale up solar PV pumping in relief operations.

This booklet is aimed to water engineers, especially those working in emergency and post and protracted emergencies with a goal to raise their awareness and understanding of the opportunities that solar PV pumping solutions bring, its advantages and disadvantages and the main issues that should be taken into account when assessing, designing, installing, and carrying out operation and maintenance work.

1. What Is Solar Photovoltaic Pumping And Why Now?

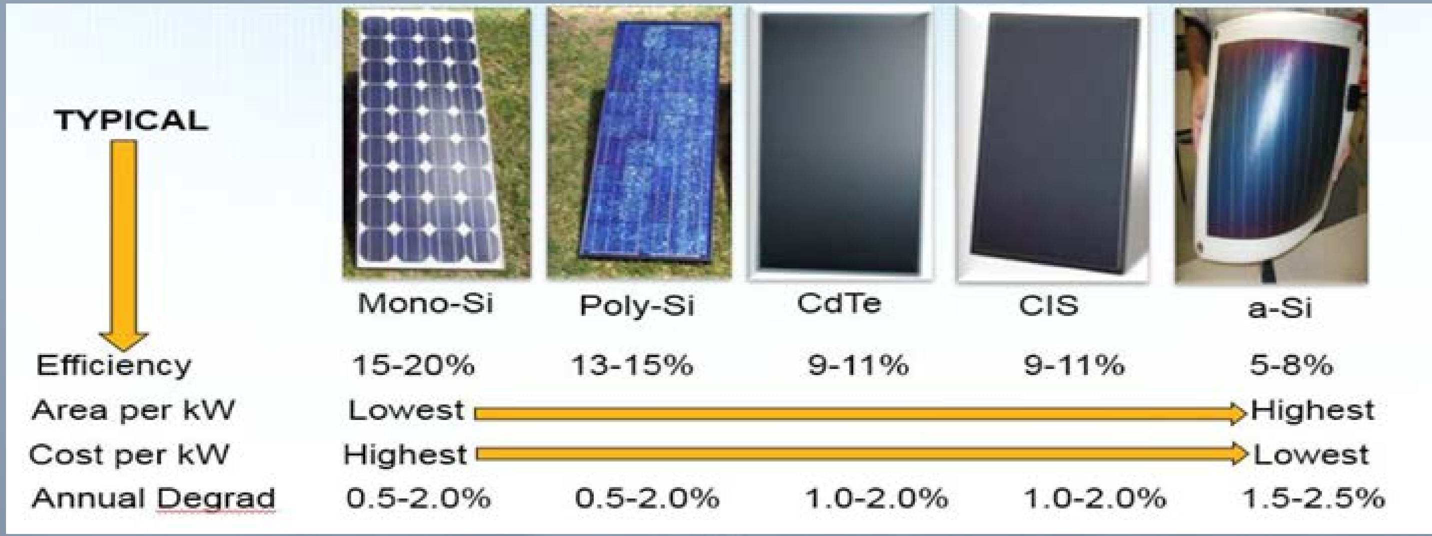
Solar photovoltaic (PV) pumping is the use of solar PV panels to generate DC electricity that can then power a water pump, as opposed to water pumps running on grid electricity or diesel generators.
Solar PV panels convert sunlight directly into DC electricity by means of the photo-electric effect.

Using sophisticated yet well-established technologies, solar energy empowers a water pump that moves water from boreholes, wells, ponds, and other water sources to either directly to consumers or, more commonly used, elevated water tanks.



There are many different types of solar panel construction, with slight different manufacturing implications and exhibiting slightly differing characteristics, but all operate on the same principle.

SOLAR



TYPICAL	Mono-Si	Poly-Si	CdTe	CIS	a-Si
Efficiency	15-20%	13-15%	9-11%	9-11%	5-8%
Area per kW	Lowest				Highest
Cost per kW	Highest				Lowest
Annual Degrad	0.5-2.0%	0.5-2.0%	1.0-2.0%	1.0-2.0%	1.5-2.5%

Solar- Powered pumping systems are the forefront of pro-poor technologies being promoted for human, livestock and irrigation applications because they are durable, easy to maintain and exhibit long term economic benefits.

Why now?

Solar pumping technology is not new and has been in use for water pumping since the late 70's. However in the recent past it has undergone a series of technical and cost developments resulting in advanced, robust, versatile, low maintenance equipment that could be considered as a default option for water provision in places with medium to high solar radiation, especially in off-grid locations, long term camp contexts or there where fuel is needed to provide water but its supply is too costly or erratic.'

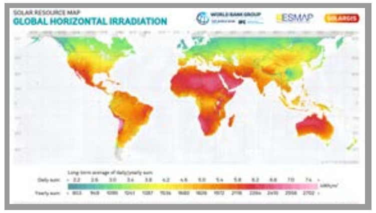
TECHNOLOGY

5. Main Factors for Renewed interest on Solar PV Technology for water pumping use:

1. **Solar PV prices Crashing:** the cost of a solar PV module has reduced by 80% over the last 10 years and it is 1% of what used to be in the early 80's.

In the last 10 years, the cost of Solar PV module decreased a 250 fold since the late 70's and 80's

2. **High and Constant Solar Radiation:** in most of the areas where relief and development organizations develop their work, the solar radiation is sufficiently high to consider the opportunity to use solar PV pumping solutions, especially in the area between 40 degrees North and South, usually referred to as the Sun Belt.



3. **Solar Private Sector booming in developing countries:** Increasing number of national private sector companies with good knowledge, expertise and able to provide good quality solar PV pumping products. This presence facilitates the implementation of solar pv pumping projects, especially when organizations do not count with the necessary experience or full in-house knowledge.

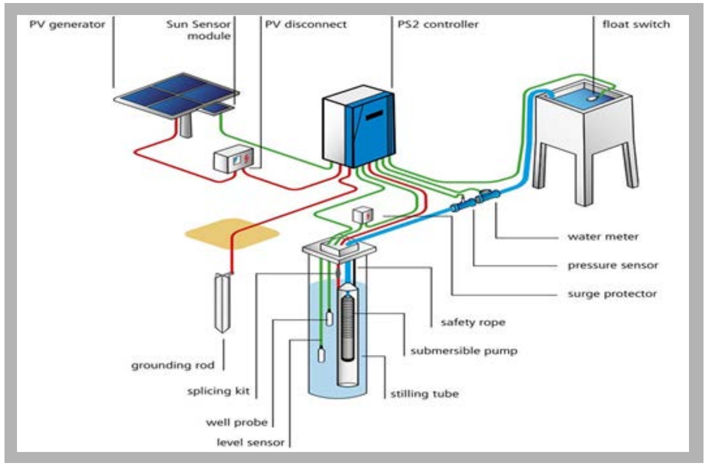
4. **Robust and reliable technology:** solar PV pumping technology has evolved in the last decade, especially solar panels and invertors, making it technically feasible to have schemes lasting for long years with minimum maintenance.

5. **Scalability:** The simplicity of the technology, quite easy to design and install, together with the cost advancements make possible to use solar pumping solutions in a high number of contexts, situations and for a wide range of depths and water requirements..

Some Facts & Figures.

25 years	**Warrantied** working life of good quality solar modules
80%	**Reduced cost** of solar modules in the last 10 years
	Cost recovery of solar pumping investments is on average **1 to 4 yrs**.
90%	**Cost reduction** over life of the systems when compared to diesel generators.
10 Years	Number of years that well constructed & maintained solar systems can function without any major failure.
+240 m3/h	+240m3/h pumping rates; solar pumping heads of +500m
USD 1,500 / Yr	**Service** agreement average **cost** with contractors to ensure functionality

Countries Where Solar Water Pumping Projects Developed By Relief Organizations Were Traced



Main components of a Solar PV water pumping scheme and possible sensors to be installed

2. When To Go Solar?

- Advantages and Disadvantages

When a reliable electrical grid is available, it is often the best choice to power water pumps. When this is not the case, onsite diesel generators have been typically the preferred option used for decades. However Solar PV is increasingly considered as a more convenient solution, offering competitive advantages over traditional fuel-based generators, especially when:

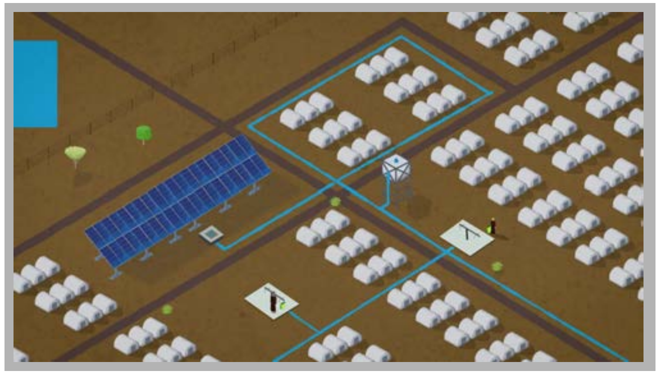
- Solar radiation is high and constant through the year
- Electrical grid is faulty or inexistent
- Fuel supply chains are erratic or too expensive
- Generator spare parts are not immediately available
- Water schemes are constructed with an aim to last for long years
- Knowledge and good quality solar products can be found at national level

Solar PV technology can be used for a variety of applications including human consumption, livestock watering and irrigation.

Context 1 – Refugee/ IDP Camps: mainstreaming of solar pumping

In camp contexts with a perspective of being in place for at least 2-3 years, solar pumping should be considered from as early stage in time as possible, whenever they are able to meet a significant amount of the water demand.
Stand-alone solar systems should be favored over Hybrid (solar + back-up power source) unless:

- Population figures are not well known or are prone to sudden increases at short notice
- Behavior of the aquifer is largely unknown
- Experience in solar pumping is low or inexistent among WASH partners or inthe area of work



In older camps, solarization of water schemes should be prioritized looking first at a) camps with high recurrent costs to ensure water provision and b) smaller schemes first, as its solarization is often more cost effective (capital investment is lower and the return period shorter than in larger water schemes).

Context 2 - Host-communities: social aspects before technology choice

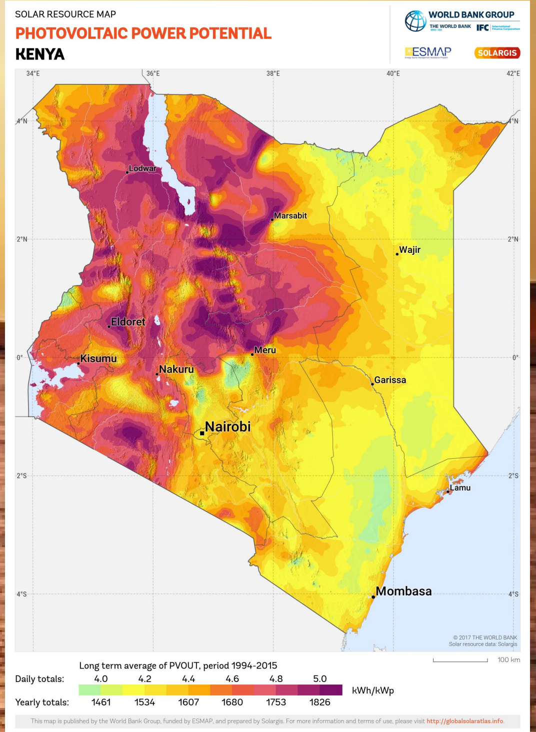
Solar pumping is, from the technical point of view, equally appropriate for water supply projects at host community level, and certainly it should be considered as a default option there where diesel generators are used, in order to increase sustainability and resilience of communities.

Solar pumping schemes record high acceptance among host communities but, as a difference with camps, aspects to do with ownership, operation and maintenance and collection and management of water fees add an extra-layer of complexity.
A well thought social approach, involving contribution from users, should come before technology choice. In this sense, prioritizing communities with strong social cohesion and coordinating approaches with government water offices should be a pre-requisite.

When solar pumping should be discouraged

Solar pumping should not be seen as a blanket solution to every water supply project, and its use is discouraged when one or more of the following cases is present:

- Where average solar radiation is so low that a solar PV pumping solution would be unable to provide a significant amount of the water required.
- When the expertise of the implementing agency is low and private sector support cannot be counted upon.
- Where theft and/or vandalisms of solar schemes is widespread reported from past interventions.
- When site specific issues [e.g. lack of space, land ownership, important shading in the area of work or others] impede proper installation of the designed solar PV solution.
- Where solar technology does not bring any significant technical or economic advantage vs existing solutions.



Tip: Google Solargis + Name of your country to get an accurate map of solar pv power potential

Current challenges:

Technical knowledge of most of water actors remains low
Measures has to be put in place in most of the cases to prevent theft of solar modules.
Availability of technicians and spare parts normally only available at capital level.
For host communities where water fees are collected, transitioning to a much more spaced use of water fees, since it might take years for breakdowns to happen, can take adjustments from partners and beneficiary host communities.

Advantages and Disadvantages of Solar PV Water Pumping Schemes

Advantages	Disadvantages
Low Operation costs since fuel is not needed and system run on sunlight	Capital costs typically higher than equivalent diesel solutions. However systems prices are increasingly dropping
No dependency on erratic or expensive fuel chain supply (avoid also the risk of fuel theft)	Most of application need water storage typically larger than for equivalent diesel systems
Low regular maintenance requirements since solar panels and invertors have no moving parts	Risk of theft of panels, that are still seen as a valuable commodity in some locations
No pollution or noise produced	System is dependent on solar radiation levels
Extended lifetime (good quality solar panels are warrantied for 25yrs, invertors typically 6-8 years)	Typically spare parts and knowledgeable technicians are only available at capital level

STORAGE

Storing energy for getting water beyond the solar day:

In circumstances where energy has to be stored, batteries are expensive and might need high maintenance. While battery technology has evolved rapidly in recent times [e.g. Ion-lithium or salt water batteries] and they come with lower maintenance and longer lifespans, they come with other challenges related to higher costs, work temperatures, lack of expertise or low to inexistent documented experience in humanitarian and rural settings. Pumping water to elevated water tanks is a way to store energy that is preferable but tanks might need to be oversized when Solar is the only power source. Hybridization of systems (solar+ diesel generators) is another solution typically encountered in off-grid areas where stand-alone solar systems cannot meet the water requirements.

Wind power for water pumping applications:

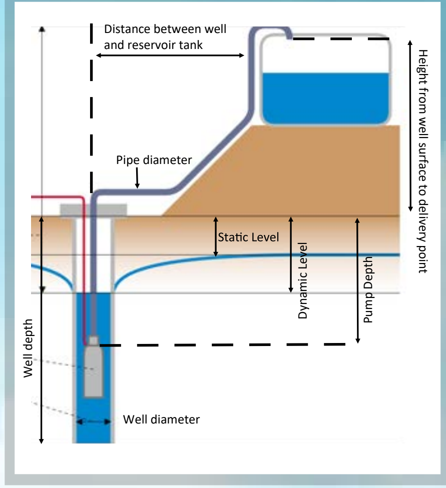
Wind power technology for water pumping is being increasingly discarded especially due to the necessary skilled regular maintenance and parts replacement required. Except for very specific locations, solar PV stand-alone (or coupled with grid or diesel generator) offer a much more reliable solution.

3. Designing Solar Pumping Schemes Sizes of Systems

When sizing a solar PV water pumping scheme, a number of parameters related to the water source must be known.

Borehole measurements needed for sizing pumping equipment

- Geographical location (GPS)
- Daily water requirements
- Drawdown and seasonality of water demand
- Safe yield of water source
- Static and dynamic water levels
- Depth of pump installation
- Total dynamic head (pump to tank)
- Distance from water source to solar panels
- Distance from source to water tank
- Elevation from source to tank
- Borehole casing diameter

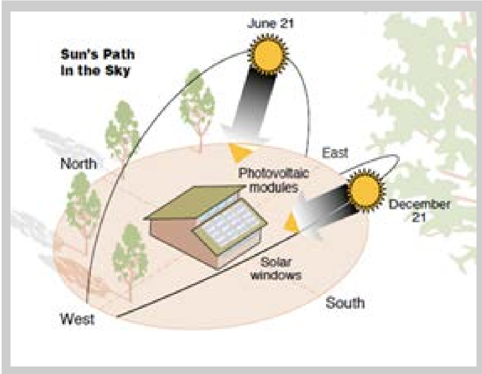


None of the data listed are specifically related to solar energy and regardless of the technology used for water pumping, all of them should be known in order to properly size the water pumping scheme.

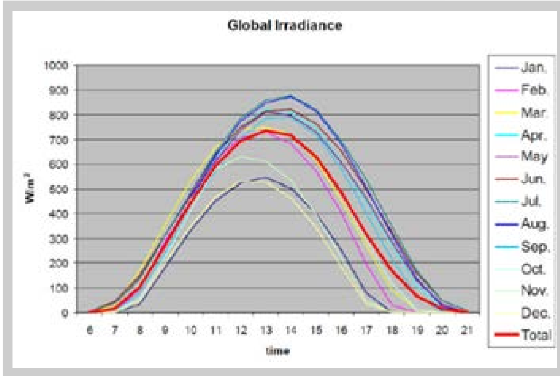
Additionally to the list provided, when sizing solar pumping schemes, solar energy available during the year has to be known as well. This data can be easily extracted from the numerous database available online. One of the most popular ones and with over 20 years of data records is the NASA one at:

https://eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi?email=skip@larc.nasa.gov

Manual sizing of solar array necessary to power the pump that was the method used till recently. However as the Sun height in the sky change over the course of a day and Sun path changes in the course of the year, solar radiation also varies, making it difficult to estimate with precision how much solar electricity (and hence water pumped) solar panels will be generating at every moment.



Typical variation of Sun height in the sky during a year



Typical variation of Solar irradiance during the day and year

A number of other influencing factors on solar electricity generation change also constantly over time, which complicate further any manual calculation. Therefore it is strongly recommended to use software based applications to do size solar pumping schemes.

Pump manufacturers, such as Grundfos and Lorentz, have developed software that can be used to estimate what can be done with good quality solar and pumping equipment in a given location. Others manufacturers are also developing similar software while the commercial software PVSyst can also be used to size solar water schemes.

Factors Influencing Electricty Production In A Solar Panel And Typical Loss In % Of Total Electricity Generated.

Losses due to:	Tempera ture	* Dirt on panels	Invertor / MPPT	Mismatch ing	Cabling	Reflectance of panels	** Shadowing	Bad inclination / orientation	Tolerance of panels	Other tolerances
Losses in %	3% to 20%	0% to 10%	3% to 10%	2% to 5%	1% to 2%	2% to 6%	0% to 2%	0% - 10%	0% to 5%	2%

***Could get up to 90% if not cleaned at all**

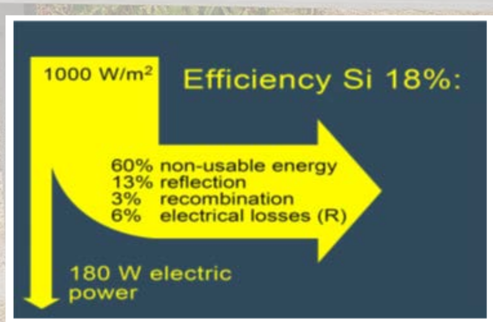
**** Could be much higher if shadow permanently casted on panels**

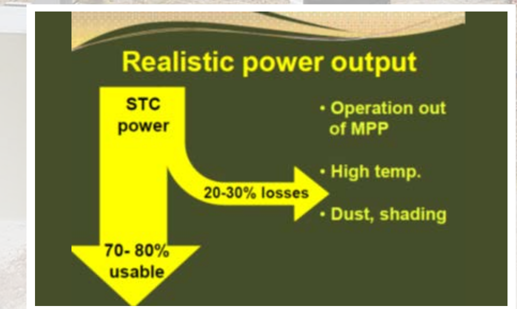
Losses

Some of these loss factors can be minimized through a well-designed and maintained scheme, for example: dirt on panels (by regular cleaning), mismatching (by using same model of panels), cabling (by minimizing length of cables), shadowing (by trimming nearby vegetation) or bad inclination and orientation of panels (by choosing the right angles for the given location).

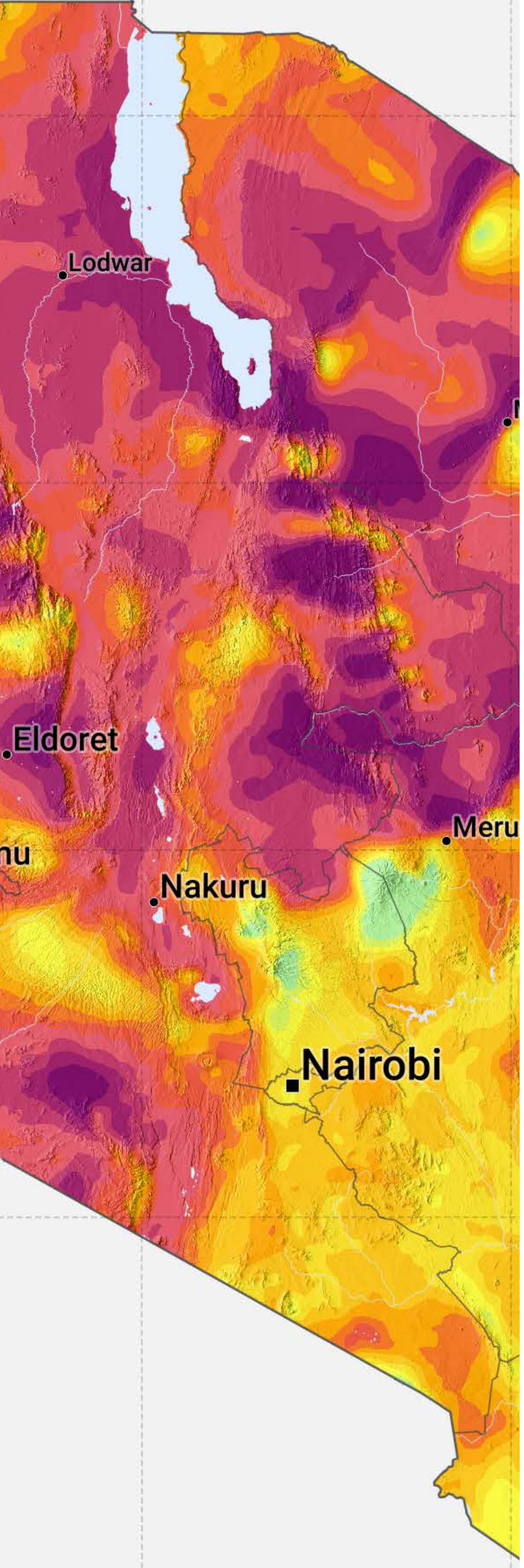
Typical losses in electricity production: (and hence water output) in a good designed and maintained solar pumping scheme will range around 20% to 30% due to a combination of the above factors, but could go up to more than 90% loss if the system is not maintained at all.

Example: from every 1,000W/m2 of Sun power reaching a solar panel with 18% efficiency, only 126W/m2 to 144W/m2 will be generated at the output of the panel.

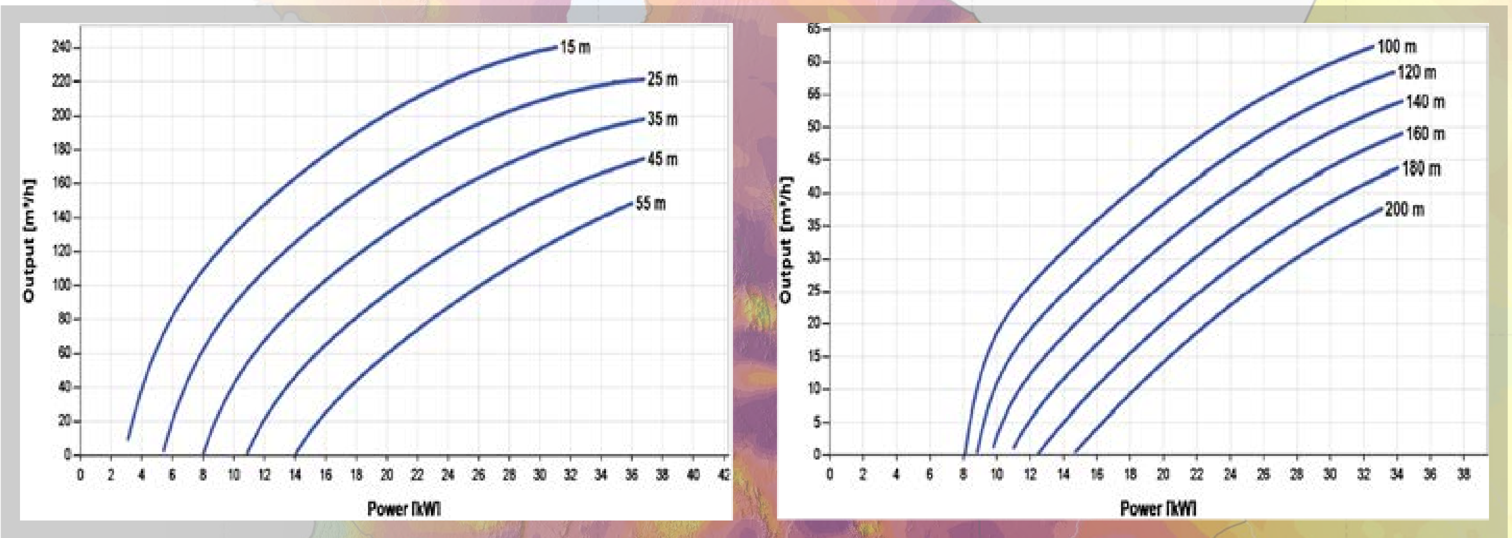




The great losses in the process explain that most of research is directed to increase the efficiency of solar panels. On average, efficiency of new manufactured panels is increased around 0.4% every year.



Size of Systems: Typical sizes of solar water schemes from off-shelf equipment ranges from +200m of total dynamic head to +240m3/h of flow. Typically these solutions are provided today by major manufacturers for pumps up to 37kW of power. For higher power pump there are still technical solutions with inverters that can be modified on demand for pumping applications running with motor pump powers of +230kW.



Graph i - Size of solar pumping systems from typical pumps and invertors designed for water pumping applications

Rule of thumb: A solar power mark-up of 1.5 to 2.4 is typically used to quickly estimate the range of sizes of a solar array for any pumping scheme. i.e. a pump motor rating = 11kW -> Solar array = 11kW x solar mark-up -> Solar array 16.5kWp to 26.4kWp.

Designing of solar PV schemes should be done for each individual water point. Caution should be taken against ordering system components in bulk and ending up having the same scheme [same pump, number of panels, tank size etc] for all the water points to be solarized'

4. Purchasing Solar Pumping Equipment

Quality of products.

Once the daily water requirements are known, the design, purchasing and installation, testing and training of users will be either done by the project implementing organization or a hired knowledgeable contractor depending on the level of expertise available. However all this tasks should be clearly indicated at the Tender document.

For organizations with low solar water pumping expertise, it's highly recommended that they just provide water requirements and leave private contractors to propose design and take the lead in all other aspects.

As organization expertise increase, private contractor role can be minimize as proposed in table below.

Organization experience in Solar Pumping	Daily Water Requirement	Design	Provision of Equipment	Installation & Testing	Handover & training to water committee
High	PIO	PIO	PIO	PIO	PIO
Medium	PIO	PIO	PC	PC	PC
Low	PIO	PC	PC	PC	PC

PC = Private Contractor / PIO = Project Implementing Organization (i.e. NGO).

Attention: If the system is hybrid (solar + diesel generator) the design to be proposed should be such that maximize the reduction of diesel demand.

QUALITY

When tendering, it is highly recommended to include the following points for solar water pumping equipment, in order to be able to compare different offers.

System Planning and Design

- Design and install systems using computer based tools and with adequate controls and protections to be able to withstand weather anomalies.
- For the location the solar array should be tilted at a (specify degrees and azimuth angle).
- The design life of the system must be 25 years. System design should eliminate as much as possible the use of components with a short life, for example batteries (typical life of 3-5 years). In this sense, solar tracking is not an option due to the maintenance requirements and risk of breakdown in the given locations.

Quality of products.

- Solar modules must be approved to IEC/EN 61215 and 61730 or UL 1703 certified and listed. All modules must be of a robust design.
- Control equipment must meet EN 61800-1, EN 61800-3, EN 60204-1 or internationally recognized equivalent standards
- Control equipment must provide diagnostic indicators and show status.

Attention: the market is flooded with bad quality solar modules. Cheap uncertified modules might drop their output only after a few months, making the system not to meet water requirements.

Note: a solar pumping scheme that works for the first 2 years, will very likely work for many more. Therefore, it is of paramount importance to ensure proper maintenance and servicing at least during that period. In this sense, servicing will be easier if solar pumping schemes are clustered in the same geographic area.

Proposed Check-Up Summary to evaluate Tender proposals.

Deliverable

1. Daily water output meet requirements
2. Full list of equipment provided together with technical specifications
3. Operation and Maintenance programme developed
4. PV modules approved to standards
5. Protection for low water level, SPU and under/ over voltage make part of system proposed
6. Control equipment quality to standards
7. Warranty of equipment detailed
8. Availability of service explain

Proposed deliverables to be provided by awarded company before last payment is made.

Deliverable

1. 2 day hand-on training provided on-site
2. Panels tilted at agreed tilt and azimuth angles (+/- 5 degrees)
3. Full testing, installation and commissioning report handed to Project Implementing Organization

5. Cost and Economic Assessment of Solar PV Water Pumping Schemes

Economic considerations are important when comparing alternative pumping methods. In many cases hydrological, or climatological factors will limit the kind of pumping system that can be used. Where alternatives exist, the evaluation of the alternatives must include both economic and technical analysis.
The high potential for cost-reduction that solar PV technology offers in many cases when compared with other pumping technologies would be only realized if analysis is based in costs over life cycle of schemes rather than on capital costs of installations only.

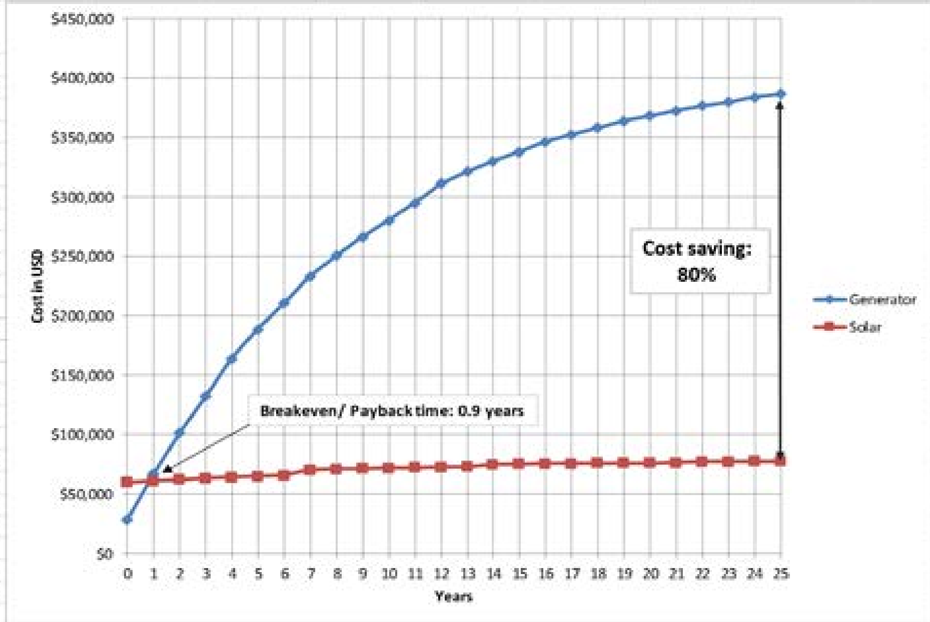
2 main concepts to be understood before taking any economic assessment:
Breakeven/ Payback time: the length of time required for the initial investment to be repaid by the benefits gained.
Life Cycle costs: the sum of all costs and benefits associated with the pumping system over its lifetime (or over a selected period of analysis), expressed in present day money. This is called the Present Worth or the Net Present Value of the system. For the system to be worthwhile, the benefits must be greater than the costs.

Attention: a detailed briefing and a tool on how to perform life-cycle cost analysis, together with examples can be found scrolling down to the Solar Working Group box at
https://www.humanitarianresponse.info/en/operations/southern-eastern-africa/wash-regional-platform-horn-africa

Graph ii – Life cycle cost analysis comparing a diesel generator pumping scheme and its equivalent solar PV system – Sudan 2017.

Cumulative Cost

Year	Generator	Solar
0	$28,811	$60,180
1	$67,451	$61,380
2	$101,950	$62,451
3	$132,754	$63,408
4	$164,455	$64,262
5	$189,011	$65,025
6	$210,936	$65,706
7	$233,500	$70,574
8	$250,979	$71,117
9	$266,585	$71,602
10	$280,519	$72,035
11	$294,859	$72,421
12	$311,619	$72,766
13	$321,537	$73,074
14	$330,392	$75,276
15	$338,298	$75,522
16	$346,435	$75,741
17	$352,738	$75,937
18	$358,366	$76,112
19	$364,158	$76,268
20	$368,644	$76,407
21	$372,649	$76,531
22	$376,772	$77,421
23	$379,965	$77,520
24	$384,267	$77,609
25	$386,813	$77,688



Cost-comparison analysis between different pumping technologies need to be done for each water point, since there are of a number of factors that influence the result, such as: country financial rates, size of systems, daily pumping times, fuel prices and location among others.

The Global Solar & Water Initiative team 'analyzed 140 water schemes in 7 countries and found:

- On average, breakeven time when comparing Solar vs Diesel range from 0 to 4 years.
- Cost reduction at the end of the 25 year period ranges from 40% to 90%.
- Hybrid systems (solar+diesel) have longer payback periods but higher net cost reductions.

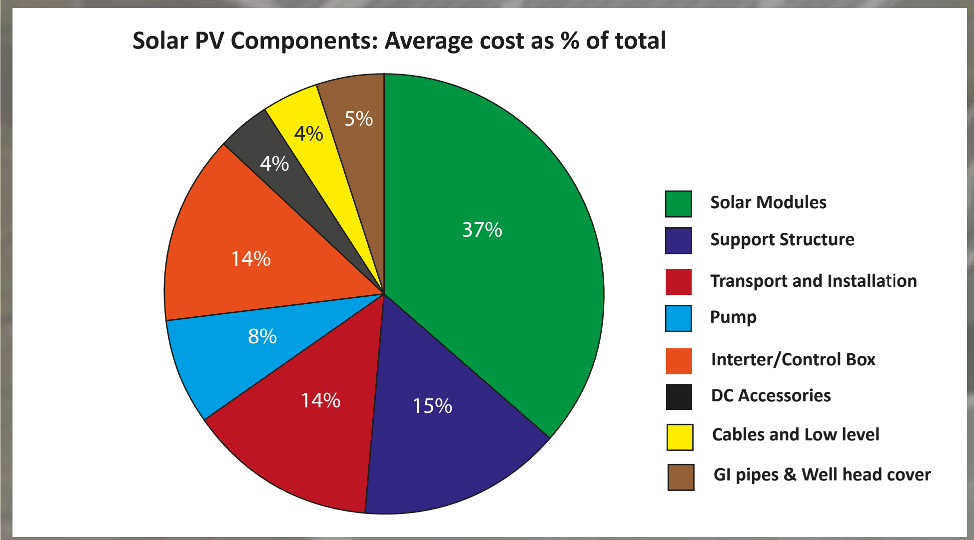
Lifespan

Table i - Data required for economic appraisal of solar and diesel powered schemes.

Economic	Period of analysis (typically all systems are taken to the longest lifespan of any of the components, 25 years for solar panels).
	Country discount rate (=Nominal interest Rate - Inflation Rate)
	Relative inflation rate (typically zero)
Cost of each component	Capital cost of each component, including transport and installation costs
	Annual Operation & maintenance (minor and major services and fuel), Overhaul, Replacement cost
	Manpower cost
Technical	Lifetime of each component

Table ii - Typical lifespan of good quality components in a Solar PV Pumping vs Diesel Generator.

Component	Lifetime		Component	Lifetime
Solar Panel	25 Years		Diesel Generator	35,000 hours
Inverter/ Control box	6-8 Years			
Pump	10 Years		Pump	10 years
Support Structure	25 Years		Pump house	25 years
Accessories	10 Years		Accessories	10 years



6. Monitoring the Installation of a Solar PV Water Pumping Scheme

In order to get a good quality solar pumping installation, monitoring the field work carried out by the private contractor selected is of paramount importance. It is therefore strongly recommended to field staff to follow up as much as possible the below list of actions.

4 main steps to ensure basic quality installations:

1) Check the references of all components of the system to ensure that the installed components are those provided in the design.

2) Check orientation and the inclination of the panels, and shadow on the Solar PV generator (acceptable variations to the design will be < 5 ° for the inclination, <15 ° for the azimuth).

3) Check the cleanliness and protection of the wiring, and its compliance with the standards.

4) Inspect civil works (castle, basin, trough, fixing the solar supports ...), piping, valves and all other important elements that can compromise the sound operation of the system.

A complete checklist for the different Solar components is developed below. To note that no previous solar technology knowledge is needed to go through each of the points so that the highest degree of quality can be assured with the minimum level of experience.

a) Solar Support Structure

No.	Subject
1.	Check if all the members of the supporting structure are of the material provided. Ensure that no parts are susceptible to corrosion. Check for proper and uniform painting of the structure
2.	Check the proper eye alignment of the support posts.
3.	Check with a spirit level the verticality and horizontality of poles and modules
4.	Check the bolting has been done at every hole
5.	Check for obvious weaknesses such as structures that are grossly swaying

b) Electrical wiring

No.	Subject
1.	Ensure cable conformity : Compare cable specifications and sections with those provided by the manufacturer for the power and the distances measured on site
2.	Check that all cable connections are inside the junction boxes provided for this purpose; no connection between two cables should be visible
3.	Ensure all cable glands and conduits match the cable size and are properly sealed. All entries into the terminal box should be through cable glands
4.	Check that all housings connections are at a minimum height of 50 cm from the ground level
5.	Choose a sample of the cable and test it by pulling on a cable out of a gland to ensure that it is sufficiently tight to hold the cable.
6.	Check that all cable terminals are properly fastened and sufficiently tight
7.	Check the cable interconnection between the modules is fastened to the structure at regular intervals by use of suitable clips or cable ties
8.	Check that all surface cabling is of armoured type and if not armoured should be placed in electrical conduits and protected using protective tiles to prevent damage from passing vehicles.
9.	Check that there are no overhead cables. All interconnecting cables should be guided to the ground and conform to point 7 above.
10.	Verify the existence and proper connection of grounding rods for both earthing and lightning surge protection
11.	Check that DC-rated components are used in the DC side of the water scheme.

c) Modules and PV array

Subject
Check the conformity of module specification in accordance with the design simulation and that all installed modules are of the same manufacturer and characteristics
Check the number of modules in series and in parallel and compare with design.
Check if the modules are well oriented (tilt and azimuth angles)
Check with if the east-west axis of the modules is properly horizontal.
Check that the height of the lowest point of the modules from the ground is greater than or equal to the height in the specifications
Check the cleanness of the solar array (each cell)
Ensure that no module is damaged: broken glass, frame, twisted, scratched
With the installer, measure the voltage output from each string and ensure it's consistent with the design and that it's uniform across all the strings
Check and ensure that every module is fastened to the structure at every bolt hole

d) Inverter or other AC interface

No.	Subject
1.	Check the conformity of inverter specifications (or interface)
2.	Check the inverter (or interface) is correctly mounted at more than 50 cm above the ground level
3.	Make sure inverter is well protected from adverse weather conditions and is as close as possible to the PV array e.g. placed in the shade of the modules. If mounted inside a room, sufficient ventilation should be provided. The inverter must not be installed inside an additional enclosure as this will lead to insufficient cooling
4.	Check that the inverter is mounted directly on a solid wall or equipped with a back plate, and that the wall/back plate can support the weight of the inverter. Check to ensure that it is also mounted in accordance to minimum spacing requirements provided by the manufacturer
5.	Ensure protective devices have been installed between the PV array and the inverter e.g. DC Disconnects, DC Breakers, Surge Protectors etc.

7. Basic Operation and Maintenance

This chapter describes steps that the scheme operator and the water point committee members should to take to ensure that the system is running efficiently.

1. Regular Cleaning of Solar Panels:


Regularly clean the panels to remove accumulated dust and other debris like bird droppings. This will improve the rate of pumping. Cleaning should be done with a soft sponge, and water. **DO NOT USE SOAP.**
Cleaning should be more regular during the dry season.

2. Trimming of trees:

Trees around the solar panels should be regularly trimmed to ensure that they do not give a shadow that blocks the panels from receiving maximum sunlight.


3. Mounting of solar panels:


Ensure solar panels are **properly secured** on to an appropriate **mounting frame with enough reinforcement** to mitigate the risk of theft and strong winds blowing off panels.

In case of loose mounting, contact a welder to reinforce the installation.

4. Clearing the area around the borehole and Solar Panels:


The compound where the solar panels and pump are located should be kept clean and free of litter and debris. Any tall grass should be trimmed to deter theft and vandalism

5. Exposed Wires:

Electricity cables SHOULD be insulated at all times. Check and cover up holes to the inverter to avoid insects and rodents from entering it.


6. Check the inverter regularly:

Clean dust the inverter using a broom and dry cloth. Check and record faults from the inverter and report to the corresponding technician. it.

When to call a technician

- When the pump is making unusual noises.
- When there is any change in the rate of pumping- The system is pumping less water than it used to yet the solar panels are clean.
- When a bi-annual maintenance check needs to be performed.

Checklist and Important Numbers

This section highlights the required documents and necessary numbers that scheme operators and committee members **MUST** maintain.

Important Telephone Numbers

- Installation Technician______________________________
- Certified PV Installer_______________________________
- Certified Pump Expert_______________________________

Important Documents

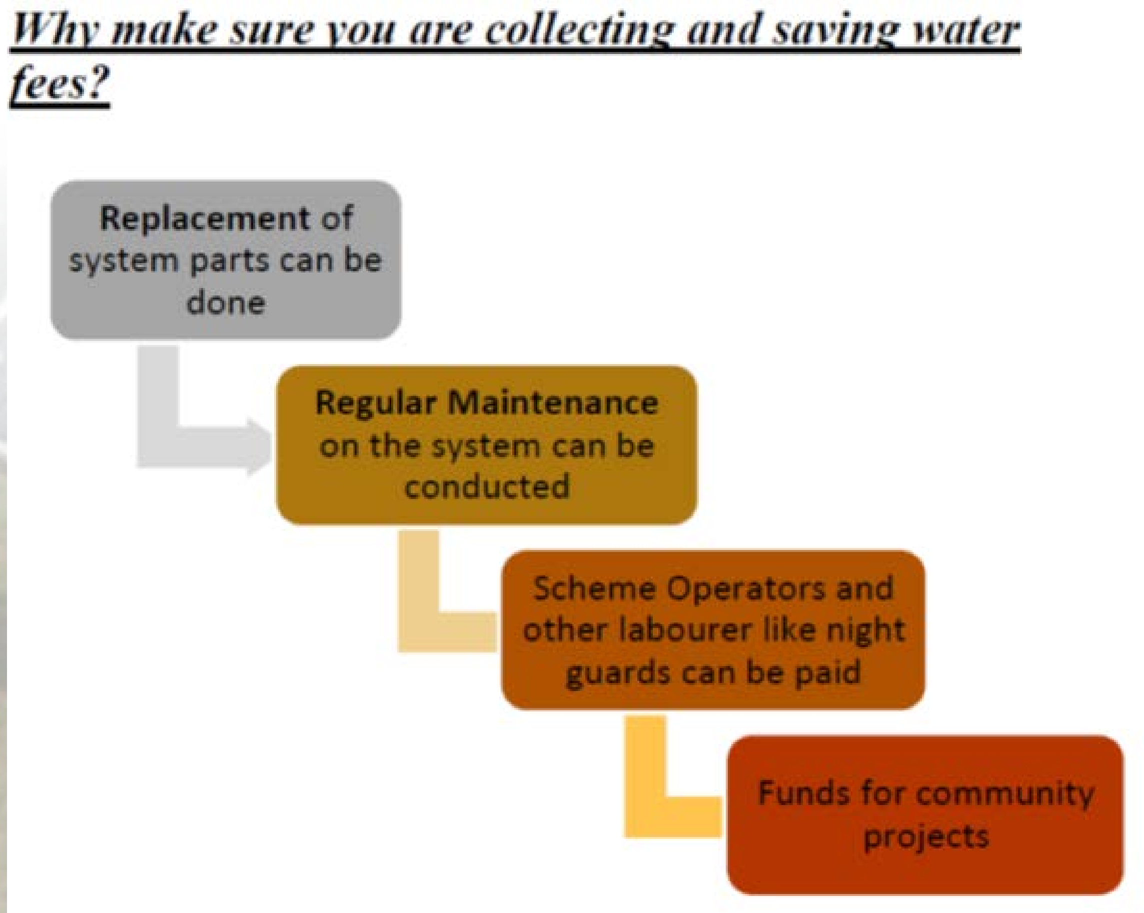
- ☐ Bank Account Registration Documents
- ☐ Equipment Warranty Certificates
- ☐ Equipment repair logs
- ☐ Pumping log / register

Important Training

- ☐ Financial Management Training
- ☐ Systems Operation Training (The scheme operator and members of the committee should be trained on how to operate the system on a day to day basis)

Providing Water at a Fee.

Water at a solar-powered pumping scheme should be provided at a fee, especially when working at local community level. Repairs, parts replacement and eventual replacement of pumping equipment or some damaged solar panel is dependent on money collected and saved over time. Lack of collection at solar-powered water points may compromise the long-term sustainability of systems.



Note: Mobile payment options and introduction of Smart taps currently developed by some manufacturers might be used to minimize the potential for mismanagement of water fees.

Myths

8. Breaking myths about solar technology and water

Myth: I can't predict water output since solar conditions are variable.
Reality: Current tools allow taking into account all changing conditions to estimate water outputs.

Myth: I can't get enough water during cloudy months.
Reality: Solar Pumping can work during cloudy days too. Weather conditions can be factor into the design to estimate whether water requirements can be met.

Myth: I know capital cost of solar is too high.
Reality: Return on investment of solar schemes when compared with equivalent diesel ones is on average between 0 to 4 years.

Myth: I need deep electrical engineering knowledge needed to be conversant with the technology.
Reality: Water engineers can get conversant on the necessary basics with a few days of training.

Myth: I have seen solar schemes not functioning because solar products break often under harsh conditions.
Reality: Quality solar panels are manufactured to withstand ambient temperatures of over 50C.

Myth: I don't see the point to use Solar in countries where fuel prices are low.
Reality: Analysis of 19 water schemes in Sudan, where fuel cost is 0.3USD/l still show an average return of investment of 3.5 years.

9. Causes of Solar Water Pumping schememalfunction

Most failures occur during or shortly after the pump system's installation and origin from faulty controller or PV wiring:

Table iii - Common reasons of failure during installation.

Loose cable connections	Bad cable splicing	Wrong Solar panels wiring	Wrong wiring of accessories/ Insufficient sealing of invertor
			

Attention: The root cause for most of these failures is easily avoidable and have to do with inadequate tools and installation materials or lack of specialized training from installer crew.

Once the installation is up and running, over time most of the problems found in solar pumping schemes are not specifically related to solar equipment, but rather to common Water Supply problems (i.e. wrong sitting of boreholes, silting, wrong design data such as safe yield etc) or else vandalism or theft of solar panels.

Also worth noting that many pump manufacturers offer product warranties, and most failures in those cases fail within the warranty period.'

Remote

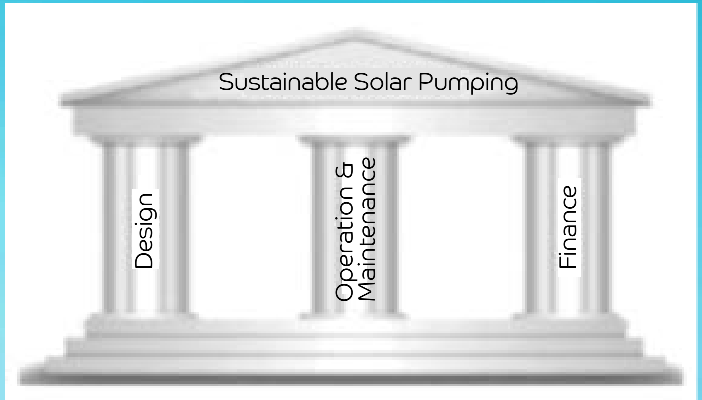
Note: Remote monitoring capabilities allow users to monitor performance, get alarms via SMS or email and have a historical record of data observed including water flow rates, pressure and water level sensors information, input power, voltage current, motor speed and pump status among others.

Note: Remote monitoring makes possible to operate the pump, monitor data and anticipate preventive maintenance as well as record data for accountability purposes from any location in the world with data phone access.

10. Recommendation and Way forward

As the solar pumping technology keeps getting more affordable and robust at the same time, it becomes increasingly ready to be mainstreamed in a wide number of countries and contexts.

However, excessive focus on the technology itself might put at risk the sustainability of these systems, which is dependent on system design, Operation & Maintenance mechanisms and financial management.



Recommendation for way forward to donors and governments

1 Base funding decision in costs over life cycle of equipment rather than on capital costs of installations.

2. As much as possible extend funding lines for a period of 2 years or more, so that the use of solar technology can be more strongly supported.

3. Create Solar Water Facility or Solar fund to bring more attention faster

4. Define clear policy brief to avoid to fund those with no expertise or in contexts where it is not suited

5. Support sustainable training initiatives to curb the lack of organizational and field expertise.

6. Support evaluations of old solar projects in order to build stronger evidence

Recommendation for way forward to field practitioners

1. Get basic knowledge on solar pumping first; get to know how to monitor private sector companies when contracting their services.
2. Think of After-Sale service scheme beforehand, focusing only on technology will put sustainability of schemes at risk.
3. At host community level prioritize places with strong community cohesion; as much as possible cluster solar pumping schemes in same geographical area to ease servicing and maintenance.
4. Analyze all factors before choosing the technology: sometimes is not about costs, but security access to water schemes, irregular fuel supplies, access to parts and expertise, inexistent or faulty grids, remoteness and others.
5. Solar pumping makes more sense in medium to long term situations. In humanitarian operations, think of solar pumping as a default option for long term displacement contexts.
6. Look at cost over life time of equipment to truly realize of economic advantages of solar pumping. Use life cycle cost analysis of different technology as a decision making tool.


ODOBU 2 REFUGEE SETTLEMENT
Safe Water Project
The Solar Powered Water Supply Project is
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unicef

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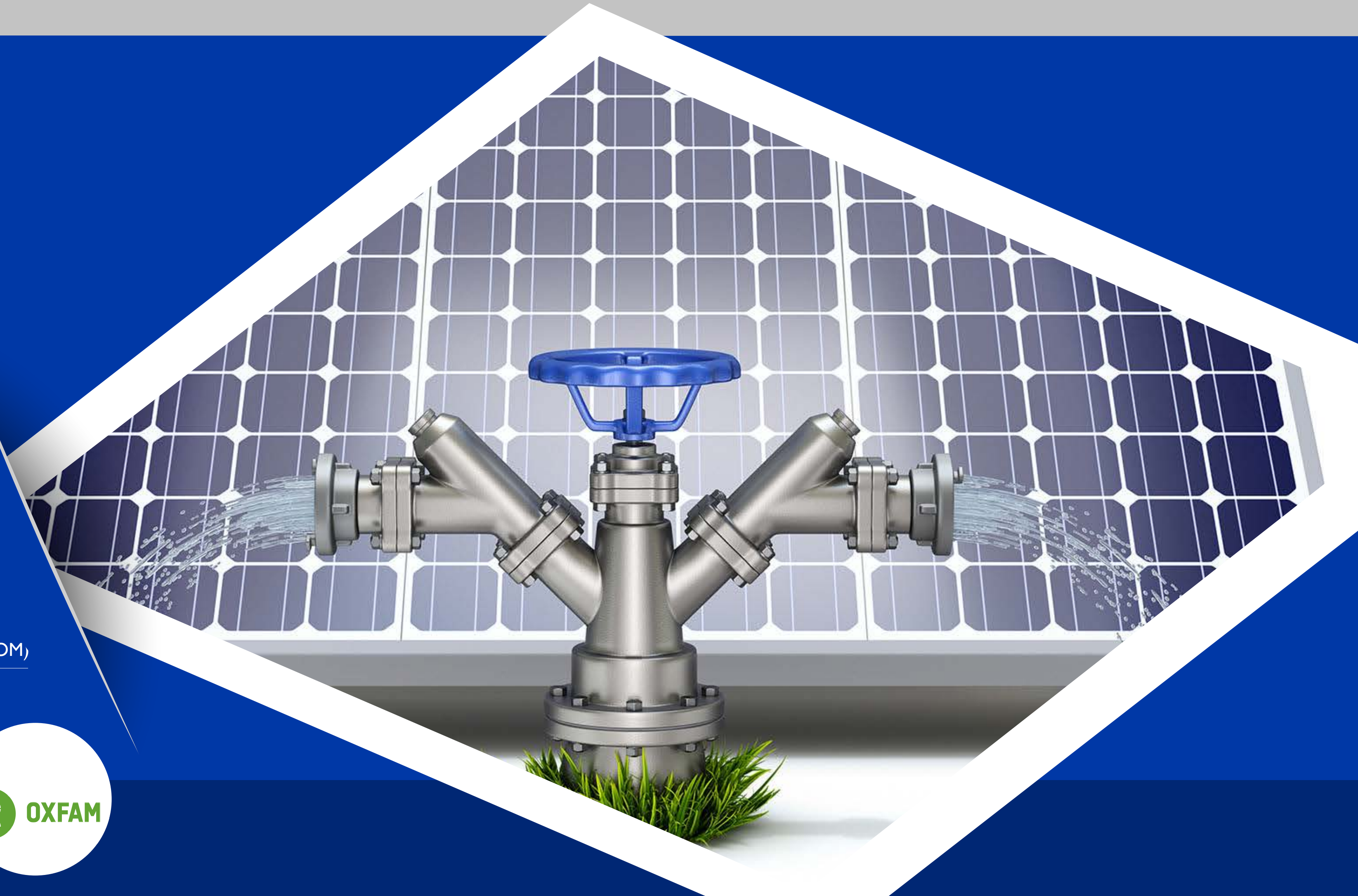

International Organization for Migration (IOM)

The UN Migration Agency

Humanitarian Aid
and Civil Protection

NRC
NORWEGIAN
REFUGEE COUNCIL

OXFAM