Factsheet Solar pump

Pages 9

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Introduction

At remote places, far away from electricity and clean water, electrical pumps with solar panels (solar pumps) can provide in a clever solution. In several projects Pico Sol gained experience with this technology. We would like to share this knowledge with you.

▲ Solar pump in Sowek, a village with 1500 inhabitants on the island of Biak, north to West-Papua.

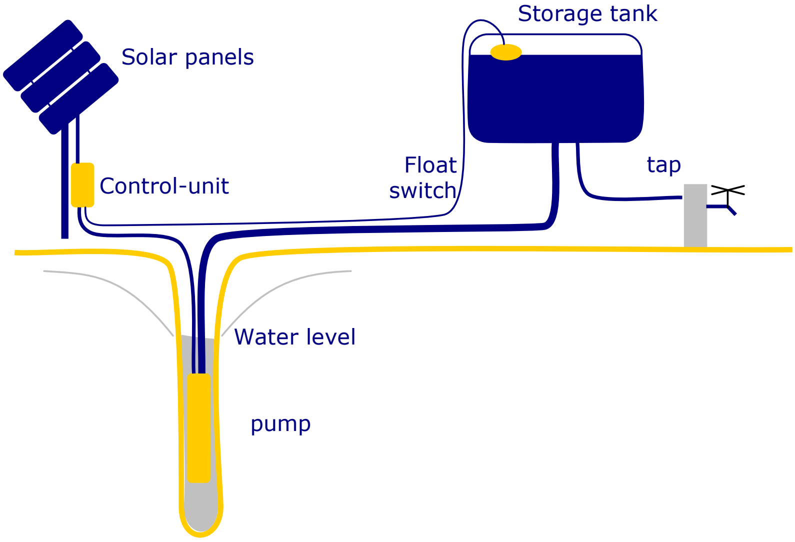
System lay-out

The solar pump system consists of solar panels on a mounting structure, a pomp controller, an electric pump and a storage tank for water.

The big advantage of the solar pump is that there is no battery necessary to back-up the solar power. The pump is connected to solar panels, so water is pumped from low to high level in case the sun shines. The water is buffered in the tank that is mounted at a higher level than the taps. In this way there is pressure on the taps and there is water available if the sun is not shining. The function of the water tank is comparable to the function of the battery.

To obtain a good match between solar panels and the pump, the pump controller is connected in between. This controller makes the solar pump a unique product. Not any other pump can be used, on the contrary! The controller converts the direct current from the solar panels into alternating current with a frequency that depends to the irradiation. At low irradiation, eg. in the morning at sunrise, the pump will be driven by a slowly rotating engine. The speed of rotation will increase when the sun rises in the course of the day.

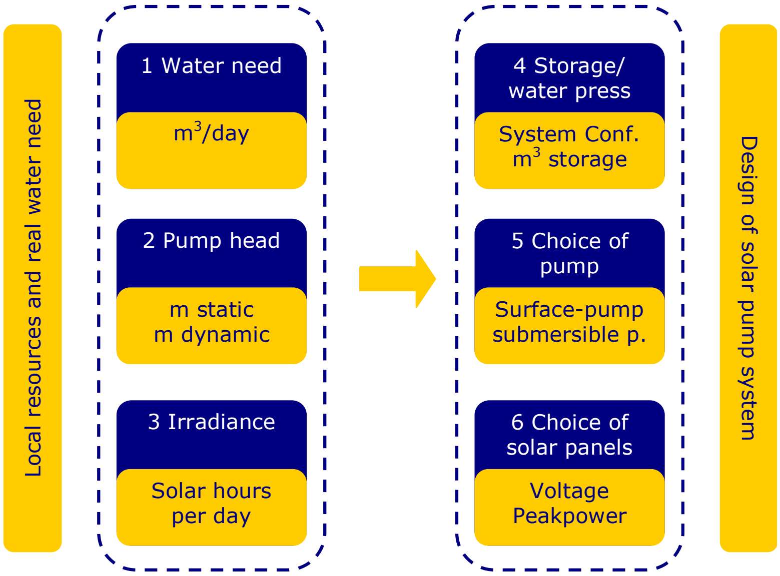
A simple float switch will switch off the pump if the water level is high enough. If the water level will go down and the sun shines, the pump will be switched on again. If the float switch does not function well, the solar pump system can be used as a shower (below).



▲ General set-up of the solar pump system

▲ Broken float switch

Design scheme



▲ Design of solar pump system starts with a survey of needs and location data (step 1-3). With this result, a most appropriate pump and solar panel combination is obtained to design the right system configuration (step 4-6).

Step 1 Water need

The first, the most logical, but also the most difficult question concerns the water requirement. Related to this question is the purpose of the water. Is it for domestic applications, for an orphanage, for a village, for irrigation? The best source for your information is to ask and measure on site. To help you finding a first indication, we can help you with some index numbers.

Westernised family	100 litres per person per day. This is including water for bathroom, shower, dishes, cloth washing and so.
Not-westernised orphanage	With 20 litres per person per day you are probably rather high

Not-westernised village	Index number of WHO: 40 litre per person per day. The real need is probably lower.
Irrigation	Not answerable with an index number. What is the crop, How much sunshine you have to compensate (evaporation) and what is the rain supply on site? These questions should be answered with local knowledge. It's also not bad to ask a specialist or to look in an irrigation manual. Also internet provides quite some information.

Step 2 pump head

Step 2 of the investigation to local resources is to answer the where-question: Where does the water come from and where should it be pumped to? What is the distance between the well? What is the water level in the well? At what height should the water be stored? To answer these questions, we distinguish the static and the dynamic head.
Total head = Static head + dynamic head (friction in the pipe)

Static head

The static head is the difference between water level in the storage tank and the well. Notice that the water level in the well is not always identical to the ground water level. If the capacity of the well is limited, the water level in the well can decrease substantially.

Dynamic head (friction in the pipe)

The pipe length between the well and tap is also relevant. The water is restrained by the friction in the pipe, especially if there are benches in it and if the inner diameter is relatively small. As a result, the total head is apparently more than the vertical difference between the water level of well and tank. The magnitude of this dynamic head depends on the inner diameter of the pipe and the flow. The table below presents the meters to add to the static head per 100 meter pipe to calculate the total head.

▼ The dynamic head in meters, per 100 meter of pipe. This head is dependent to the combination of inner diameter of the pipe and the flow. The table gives the values of plastic pipe. (source: Bernt Lorentz GmbH)

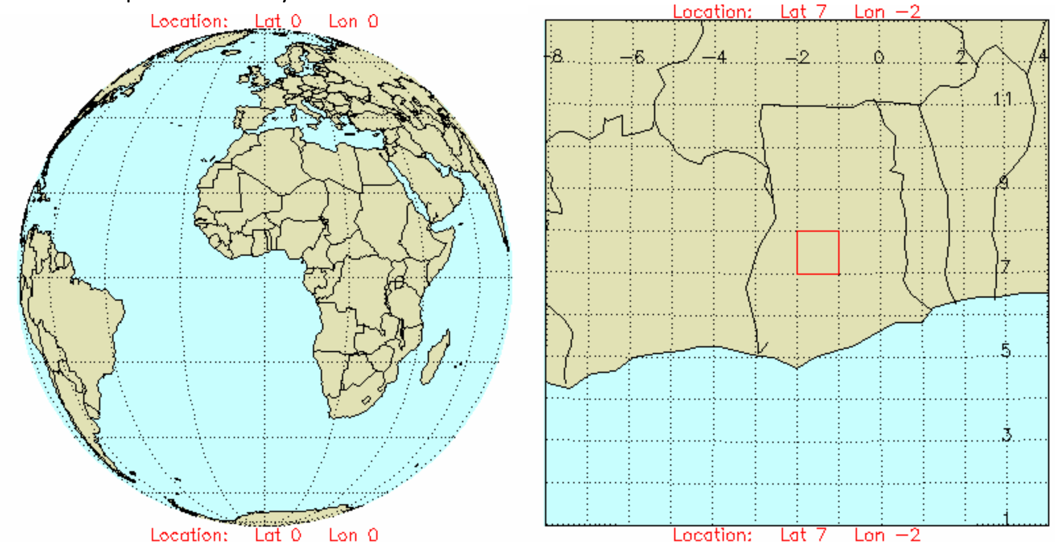
Flow	Inner diameter of the pipe in inches (1 inch = 25.4mm)						
Litre / minute	0.5	0.75	1.0	1.25	1.5	2.0	2.5
3.8	1.0	0.4	0.1	0.02			
7.6	3.0	1.2	0.4	0.10	0.05		
11	6.0	2.3	0.7	0.20	0.10		
15	10	4.0	1.2	0.32	0.15	0.05	
19	16	6.0	1.8	0.48	0.23	0.07	
23	22	8.0	2.5	0.67	0.32	0.10	0.04
27		11	3.2	0.89	0.43	0.13	0.06
30		13	3.9	1.1	0.51	0.16	0.07
34		16	4.9	1.3	0.60	0.19	0.08
38		19	5.9	1.6	0.80	0.24	0.10
42		23	7.0	1.9	0.90	0.28	0.12
45		26	8.0	2.2	1.0	0.3	0.14
53			11	2.9	1.4	0.4	0.18
61			14	3.7	1.8	0.5	0.23
68			16	4.5	2.2	0.7	0.28
76			20	5.4	2.6	0.8	0.34

Flow Litre / minute	Inner diameter of the pipe in inches (1 inch = 25.4mm) 0.5	 0.75	 1.0	 1.25	 1.5	 2.0	 2.5
83			23	6.4	3.1	0.9	0.40
91			28	7.5	3.6	1.1	0.47
99				9.0	4.2	1.3	0.54
106				10	4.7	1.4	0.60

Stap 3 Irradiance

The irradiance is obtained from the internet. The NASA developed a database based on information from satellites (cloud configurations during a long period). The database gives a good estimation of the solar irradiance on the ground. To find the relevant data, we direct you through the next steps. The result will be a table with monthly averages of the amount of "full sunny hours" at your project site.

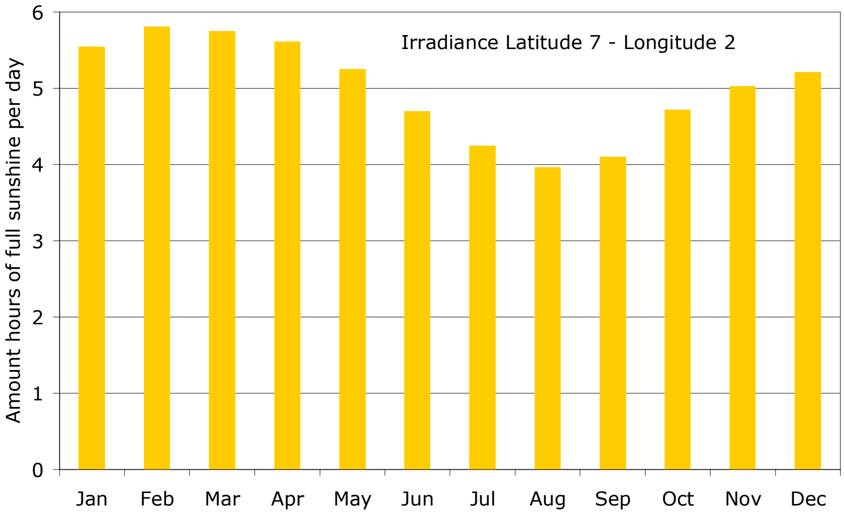
- Website: http://eosweb.larc.nasa.gov/sse/
- Click on Renewable Software Application Inputs
- Click on Retscreen International data access
- Register yourself as user
- Now you will enter a screen, in which the Longitude and the Latitude should be given. To know these numbers, you can also use the tool 'Pick a location graphically'. At zoom level 16 you can give your location quite accurately.



▲ Tool for looking up the co-ordinates of your project location.

- Now you click on 'Submit for data'
- You will obtain a table on your screen with the monthly averages of various meteorological parameters. The most important is the third column of this table 'Daily solar radiation - horizontal kWh/m^2/day'. This column presents the irradiance.

In the figure below, this third column of the table is presented in a graphical way

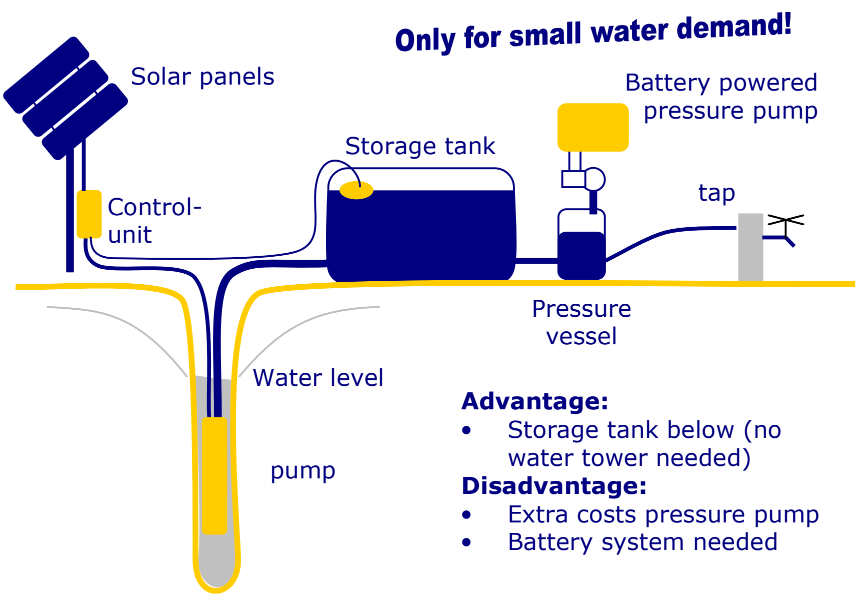


▲ Irradiance on project site Ghana (7ºLatitude -2º Longitude) in 'kWh/m^2/day'. This unit can be translated into 'hours of full sunshine per day'. Full sunshine is defined as irradiance of 1kW light energy.

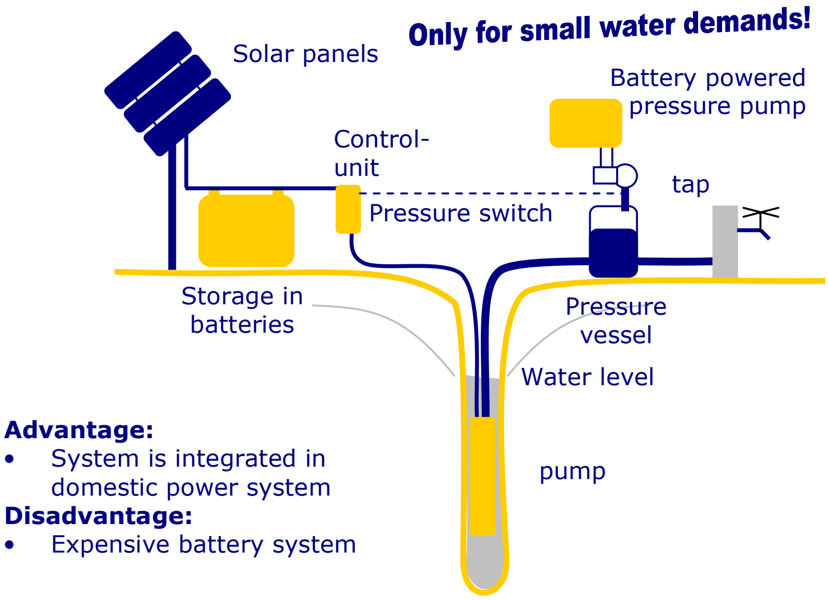
Step 4 System configuration

The capacity of the storage tank will determine the reliability of the water supply. As a rule of thumb, this capacity should be the double of the estimated daily water demand.

The figure of page 1 presents the general system lay-out. The scheme is based on storage in a buffer tank. In fact storage of water at a certain level is a method to buffer solar energy in potential energy. The main advantage is that no batteries are needed. Moreover, there is always water pressure at the taps. (on the condition that the level of the taps are enough under the tank level). There are more methods applicable, as is shown in the figures below.



▲ Alternative system configuration. The pressure on the taps is provided by an additional pressure pump and pressure vessel. This system is only viable for relative small domestic water demands.



▲ Alternative system configuration. The pressure at the taps is provided by the pump directly. The energy is stored in batteries. A pressure vessel with pressure switch will control the switching off of the pump. This system is only viable for relatively small domestic water demands.

Step 5 Choice of the pump

For the selection of the right pump, we limit ourselves to the programme of the German solar pump specialist Bernt Lorentz (www.lorentz.de). Pico Sol has built up good experience with these pumps: Reliable pumps with excellent service. There are also other manufacturers, like Grundfos en Conergy. An interesting introductoin for these pumps is found in the website of Oasis Montana (www.pvsolarpumps.com), surely worth your visit.
The pump selection is mainly based on the water demand and water head.

Surface mounted pump

At lower pump heads (typically some meters, maximal 14 meter) a surface mounted pump could provide the best solution. The Bernt Lorentz-programme offers the PS600-Badu-Top 12. On the website product information and tables are presented with the expected performance, as a function of the pump head, solar capacity and solar panel.

◀ Bernt Lorentz's surface mounted pump. Dependent on the solar panels and the pump head, this pump can pump up to over 100 m^3 per day.

total lift (static+ dynamic) [m / ft]	Solar-Generator [Wp]	irradiation [KWh/m²/day]	Sol [m³/day]	
2 / 6,5	340	4.5	54.0	
		6.0	70.0	
		7.5	82.0	
	400	4.5	61.0	
		6.0	78.0	
		7.5	92.0	
	480	4.5	71.0	
		6.0	90.0	
		7.5	105.0	
	600	4.5	85.0	
		6.0	105.0	
		7.5	120.0	
	720	4.5	95.0	
		6.0	117.0	
		7.5	129.0	
4 / 13	340	4.5	27.0	
		6.0	43.0	
		7.5	56.0	
	400	4.5	36.0	July in Ghana
		6.0	52.0	February in Ghana
		7.5	67.0	
	480	4.5	46.0	
		6.0	65.0	
		7.5	80.0	
	600	4.5	60.0	
		6.0	80.0	
		7.5	97.0	
	720	4.5	73.0	
		6.0	94.0	
		7.5	108.0	

Submersible pump

At larger pump heads, the submersible pump is a better choice. This pump goes under water in the well or borehole. Bernt Lorentz's programme offers a wide range of pumps, each with it's own flow-head characteristics. Depending to the depth of the well and the power of the solar panels these submersible pumps can pump up to 50 m^3 per day, and up to a total pump head of 240 meters.

▲ Bernt Lorentz's programme for submersible pumps. Left: The stacked centrifugal pump; Right: The helical rotor ("cork-screw") pump

solar generator	vertical lift		5 m 16 ft		10 m 33 ft		15 m 50 ft		20 m 65 ft		30 m 100 ft		40 m 133 ft	
	array mounting		fixed	tracked	fixed	tracked	fixed	tracked	fixed	tracked	fixed	tracked	fixed	tracked
			flow rate [m³/day]											
720 Wp	irradiation kWh/ m²/day	7.5	87	125	66	93	42	61	33	47	24	30	20	29
		6.0	76	106	54	78	35	50	26	36	20	26	18	25
		4.5	59	80	39	53	25	34	22	30	17	23	16	21
	pump type		C-SJ8-5				C-SJ5-8				HR-14			
	peak flow rate [l/min]		175		145		95		75		44		43	
	wire size/max. length		4mm² / 20m #10 / 85ft						6mm² / 55m #10 / 130					
840 Wp	irradiation kWh/ m²/day	7.5	96	133	74	110	57	85	40	60	24	30	22	30
		6.0	84	110	63	91	45	65	33	47	22	29	21	28
		4.5	68	92	46	62	30	41	25	34	20	26	18	24
	pump type		C-SJ8-5						C-SJ5-8		HR-14			
	peak flow rate [l/min]		185		170		150		95		45		43	
	wire size/max. length		4mm² / 20m #10 / 85ft						6mm² / 55m #10 / 130					

▲ Part of the design table of the PS-600 pump for pump head of 30 meter. At installed power of 840Wp of solar panels this pump supplies 20 to 24m^3 water per day, dependent of the irradiation. These characteristics are online available at Lorentz's website www.lorentz.de

Step 6 Choice of solar panels

The type and amount of solar panels follow from the previous step, where the type of pump has been determined. Two conditions need to be fulfilled:

The voltage should be within the window that is required	The system voltage is determined by the number of solar panels that is connected in series. A panel with 36 solar cells has a ´nominal voltage´ of

by the controller	12V (because this number of cells is required to charg 12V batteries). So, to obtain a nominal voltage of 48-72V, 4 to 6 of this type of panels should be connected in series.
Sufficient peak power	The total power of all panels should be in accordance with the design scheme of step 5.

Optional: A solar tracker

Sometimes it makes sense to consider a solar tracker. The solar panels will track the sun, so always the optimal irradiation is caught by the solar panels during the day. In the early morning, the solar panels are faced to the rising sun, to build up sufficient power to bring the pump into motion. In this way, the effective operational pump hours will be increased. The daily harvest will increase substantially, up to 40%.
This cost advantage (saved solar panels) of the solar tracker should be compared with the extra costs of the tracker. Also the introduction of a potential trouble factor should be considered.

▲ Left: Solar panels on a tracker system can lead to an increase in performance up to 40%. Right: A static established solar panel system