Humanitarian Aid
and Civil Protection

Global Solar and
Water Initiative

Global Solar and Water Initiative

Visit Report - Refugee and IDP Camps in Maban, Yida and Bentiu –

South Sudan, 3rd to 20th July 2017

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1. Executive Summary and Recommendations.

The Global Solar and Water Initiative team undertook a visit to South Sudan in order to assess selected existing solar pumping schemes, evaluate the feasibility to solarize water supply points in selected camps and raise awareness and solar technical expertise among WASH stakeholders in the country.
28 water supply schemes were visited in 7 locations: 26 in camps plus 2 solarised community systems in Pariang County.
Out of the 28 visited only 5 were running exclusively with generators.

Solar pumping has been extensively used in camps in South Sudan for the last years.

Security incidents in Bentiu POC camp hindered visits to 4 functional water supply points, 2 of which were being solarized.

The visit entailed collection of relevant data needed for full techno-economic analysis of the systems, in order to determine feasibility for solar pumping as well as gauge the design and performance of solarised schemes. Absence of basic data such as safe yields, water outputs (disaggregated in case of hybrid systems) or water levels made not possible to analyse all the visited water points, especially in Maban. Its absence put into question the basis for some of the existing solar designs.

Climatological and hydrogeological conditions in the locations visited were favourable, making the use of solar pumping a technically feasible solution for each and every borehole and surface scheme assessed.

Wide support and prioritization given by some donors to solar solutions in South Sudan, together with a high solar irradiation through the year make the context good to use solar pumping in the country.

Other enabling factors in favour to the use of solar pumping are summarized in the following table:

CLIMATE & HYDROGEOLOGY All boreholes analyzed conducive to be solarised	**SOLAR PRICES** -Surprisingly- competitive prices of solar equipment in South Sudanese market	**NATIONAL TECHNICAL EXPERTISE** Available in the Private Sector at capital level.
INVESTMENT IN SOLAR Solar pumping not new in South Sudan, projects since 2006	**RELIABILITY OF TECHNOLOGY** Presence of high quality products in South Sudanese market	**CURRENT CONTEXTUAL SITUATION** Erratic and expensive fuel supply, absence of grid, absence of parts for handpumps, difficult access (rain, security)

Following the visit, a technical and economic analysis of the water points was carried out. The technical analysis took into consideration the water demand based on the population data provided by implementing agencies as well as either the safe yield of the boreholes -when available- or the current pumping rate, in order to ensure over-abstraction would not occur.

From the economic point of view, a Present Worth analysis over the longer lifespan of equipment (solar panel, 25 years) was carried out, using an average Real Interest Rate of 12% (World Bank data, details of methodology in annex A). This rate implies an amelioration of economic conditions over time; in case this would not become true, the case for solar would be stronger since future costs related to O&M are much lower for solar systems than for diesel ones.

Solar material prices were received from private sectors players in Juba and these were used against existing quotations given by implementing agencies to prepare a generic pricing matrix for the analysis.

1.1 Existing water schemes powered with stand-alone generators.

A visit to 5 schemes powered with generators alone, with proper data recorded by the implementing NGO, was carried out. Recommendations were produced to motorize them all with either small or medium-sized solar stand-alone or solar-diesel hybrid systems (see Table 1).

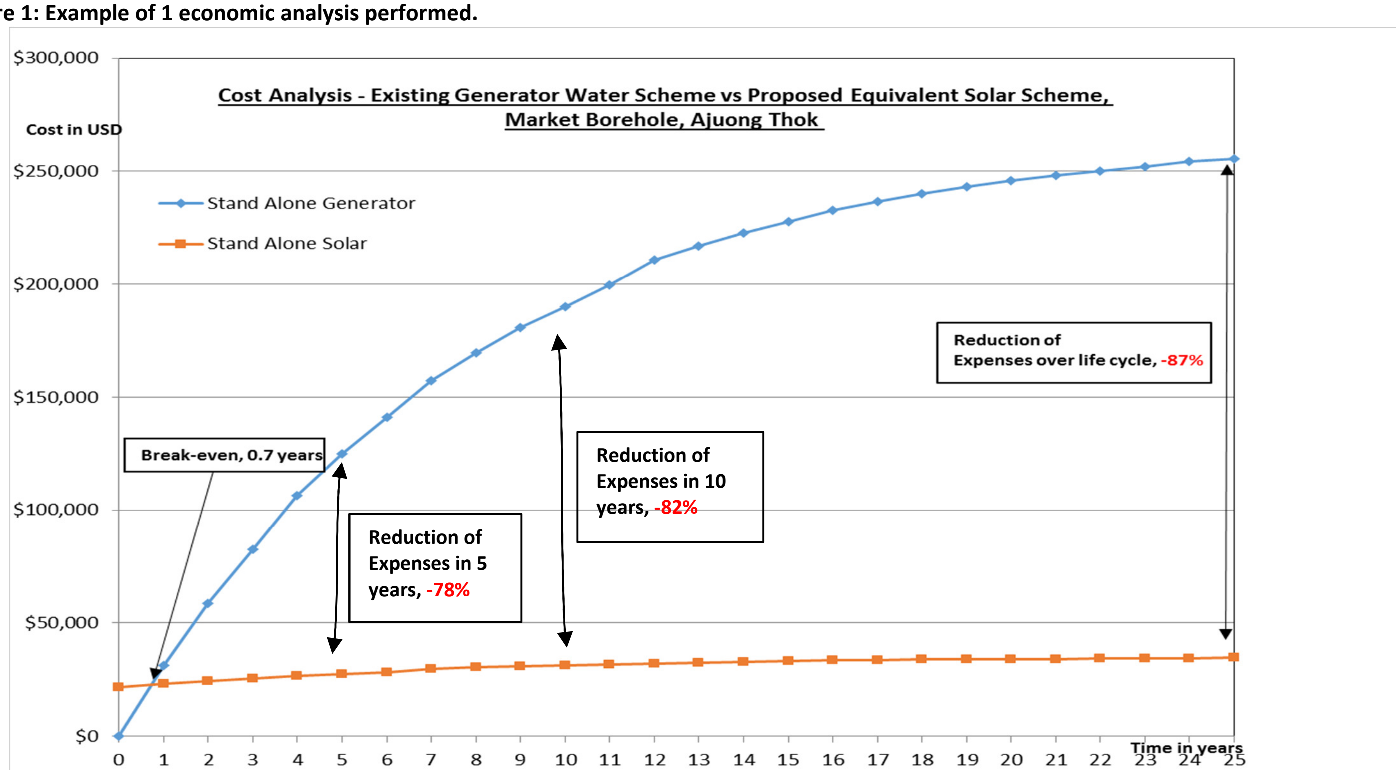
An economic analysis was run comparing the proposed solar/ hybrid systems with the existing stand-alone generator ones.

The analysis shows an average breakeven point for the solar investment of 1.4 years, and an average reduction of overall expenses (capital costs plus O&M over time) of -53%.

In other words, overall cost of the solar systems proposed is less than half of their equivalent diesel generator ones. The main contributor for these clear advantages is the relative high fuel cost in all regions of South Sudan together with the relative good pricing of quality solar products at Juba level.

With such short Return on Investment, if context analysis allows and where camps will be open for more than 1 to 2 years, extensive use of solar energy at water points is the way forward, even if only considering the narrow timeframes of humanitarian donors, and especially in locations where fuel cost is over 2 USD.

Figure 1: Example of 1 economic analysis performed.



It is clear also that the more organizations can maximize solar water output of each borehole, the shorter the Return on Investment will be and the more cost-effective the scheme will prove.
Besides cost factors, higher attention should be given to places where security of equipment and its maintenance can be better warranted, and especially if fuel supply is erratic.

It is also to note that given the context, priority of solar-diesel hybrid systems (as opposed to stand alone solar ones) should be given in camps where population figures are not well known or can significantly increase in the short term, where the behaviour of the exploited aquifer remains largely unknown or for isolated boreholes where malfunctioning of the system would have severe impact in the served population.

Otherwise and whenever possible, stand-alone solar systems should be prioritized as they are the most cost effective solutions and the payback period of the investment cost is shorter. A well calculated safe yield coming from a proper 72h pumping test is a critical factor for the right sizing of any solar scheme, and this should come before proposing any definitive technical design to mechanize a borehole.
Of note is the potential to fully solarise Yida, Pamir and Ajuong Thok refugee camps as they are in a more stable region, are expected to be in place for several years and pumping rates and times look ideal to Solar in a good number of borholes.

In addition, it has to be considered that mismanagement of fuel supplies and theft of batteries is a common issue; therefore, any option involving adoption of solar technology will limit this problem, with cost-savings likely higher than the ones expressed in the analysis below.

Finally other aspects beyond economic considerations (such as sustainability, reliability, possibility of running equipment regardless of access to area and environmental issues) should be discussed in favor of the solar option.

1.2 On existing solar pumping schemes.

Solar water schemes have been implemented in South Sudan since at least 2006. While most of the systems that did not involve the use of solar batteries where in working order, a number of problems were still encountered, namely: greatly oversized generators in hybrid systems, systems underperforming due to undersized solar PV generators (3 schemes) and solar panels wrongly oriented (5 systems), showing poor technical analysis at the time of design. The low solar technical expertise encountered among humanitarian WASH staff might explain these problems.

The absence of data (safe yield and water output) in most of the cases, and especially in Maban, made not possible to carry out the analysis to see whether the solar potential of the water points were maximized.

It terms of costs, it should be noted that the economic analysis done for the existing solar systems (see Table 4), show that all of the solar schmes installed in Ajuong Thok, Pamir and Bentiu, as well as Samari BH at Doro in Maban, have already paid back the solar capital investment.

To note the case of the central storage point in a refugee camp in Maban: while high quality solar pumping equipment is available at Juba private sector, that scheme was equipped using solar products imported from Norway. As a result the system has been non-functional for the last 5 months as there are no parts or knowledge available in the Region to service it. With no added value in terms of performance or cost, this shows that it does not make sense to import alien brands in the South Sudan context.

The other common issue encountered included several collapsed solar support structures and blown off modules due to severe storms, strong winds and wrong module orientation, bringing to light the need for field teams to have skills to be able to correctly monitor installations and to clearly state in contracts with contractors the liability for such cases.
Finally, and on the issue of theft of panels, measures taken by the WASH organizations seem to be working well, with panel theft fairly minimized (as opposed to fuel and battery theft, which seem to be a more appreciated commodity).

1.3 Solarizing narrow diameter boreholes.

A key challenge encountered was the prominence of <4” borehole casings that have limited the use of solar pumping, leading to the use of slim 3” AC pumps coupled to batteries, in Maban (Grundfos SQ family, not to be confused with the SQFlex).

The widespread failure and/or theft -with 5 out of 7 systems found non-functional only 6 months after installation- defeats the purpose of increasing sustainability and reliability through adoption of solar. The analysis indicates that the drilling of a new wider borehole and installation of a proper solar pump without batteries is a more cost effective option. Alternatively, keeping a stand-alone generator system in place would also make sense for the Maban case, where diesel is less expensive and supply is reliable.

Such case shows the need to have a clear understanding of benefits and challenges associated to solarised pumping systems beforehand, and should prevent partners to think of solar as a blanket next step for all water schemes in South Sudan.

Overall, it will important for organizations to ensure that borehole casing is matched to the potential yield of the borehole during construction phase i.e. high yielding boreholes installed with 6” casing or higher, to avoid such costly situations.

1.4 Solar Pumping at Community level.

Some organizations expressed the willingness to introduce solar pumping at local community level. While technical solar pumping offers similar advantages as in camps, working at community level has an extra-layer of complexity related to the O&M of equipment.
Contrary to the widespread idea that once installed, solar schemes will last long years on their own, after installation support is important especially from the first 18-24 months to ensure long lasting solar schemes.

Therefore, when considering to use solar at host community level, supporting technology alone is not a recommended approach since models for proper O&M should come before technology.

A well thought approach, involving contribution from users and a good system to provide after sale support when needed (either from district water office, water utilities or private sector companies) is of great importance, as most likely communities won't be able to solve certain problems on their own, even if trained.

Insecurity and the absence of government and community mechanisms of ownership are factors that play against solar pumping and should prompt a case by case context analysis for the implementing organizations.

Prioritization should be given to locations that have apparent relative peace and stability. Long term sustainability due to lack of local ownership (both government and communities are 100% reliant on humanitarian agencies for implementation and maintenance) poses the biggest challenge for solar systems in South Sudan and priority for solarisation should be given to locations where such agencies will be present over prolonged periods.

Agencies intending to undertake such projects should also have a management plan in place in the form of a service and maintenance schedule with local private sector (or other relevant and knowledgeable party), for sustainability.

1.5 Other issues.

The single most important barrier towards a successful solarization of water points in the camps is the low solar technical expertise of WASH field teams involved in water supply projects.

WASH organizations are heavily reliant on the private sector to provide solutions which has the risk of commercial interests taking precedence over optimal solutions.

In addition there has been an ad hoc approach towards adoption of solar pumping without proper life cycle analysis to inform decisions and funding. In this sense a 3-day training was conducted in Juba, with the presence of 29 WASH officers coming from 14 WASH organizations. Tools, documents and contacts for remote technical support were provided during the training.

However it would be important that all organizations and specially coordinating agencies build their own technical capacity and take a lead to organize refreshment trainings.

This could be done by taking advantage of the knowledge already present at private sector level and widening and adapting the scope of these trainings to address real problems encountered in the field.
Besides, capital costs can be reduced through bulk procurement and/ or signing of framework agreements to get large quantities of solar panels at once, as solar panels represents 35 to 50% of costs in any solar pumping scheme and they can be used in any water point (unlike pumps or inverters that are specific to each water point characteristics).

Finally, the use of remote monitoring is to be considered in selected critical and/or distant boreholes.

1.6 Recommendations.

For implementing organizations:

- Build technical capacity in order to know what designs, products and layouts are the best suited for every borehole. In addition build the technical capacity of technicians to be able to trouble shoot and repair simple solar failures.
- Favor 1-supplier policy for complete supply installation, using quality equipment for purposes of warranty, after sales support and training.
- Ensure after sale support service for the first 18-24 months after installation in the contract at the time of tendering or purchase e.g. 1 year warranty and free of charge service and training, followed by 1-2 years paid for service contract.
- Ensure regular monitoring of water levels, at least in the most critical boreholes, considering the possibility of using remote monitoring technologies.
- Look at lifecycle cost analysis to attract funding and in making decisions for solar pumping adoption.
- Adopt familiar quality technology that is readily available and can be supported from within the country.
- Prioritize solarization for locations where there is relative peace and stability, strong social cohesion, where fuel costs are higher or its supply is erratic.

For coordinating organizations:

- Name/recruit a focal solar person at organizational level. Reinforce inter-agency collaboration among partners, in order to build up internal technical capacity. Tap into the private sector to organize workshops and trainings and raise technical expertise among relevant NGOs and government technical staff.
- Coordinate solar work (possibly through a solar working group) in order to, among others, provide technical guidance for the standardization of solar pumping design, installation, care and maintenance for all WASH actors in South Sudan.
- Coordinate Mapping of areas with higher potential for solar adoption in order to prioritize funding.
- Assess different modalities for buying solar panels in bulk (at country level or through regional offices)
- Build up evidence through supporting evaluation of existing older solar systems.

For Government/ Donors:

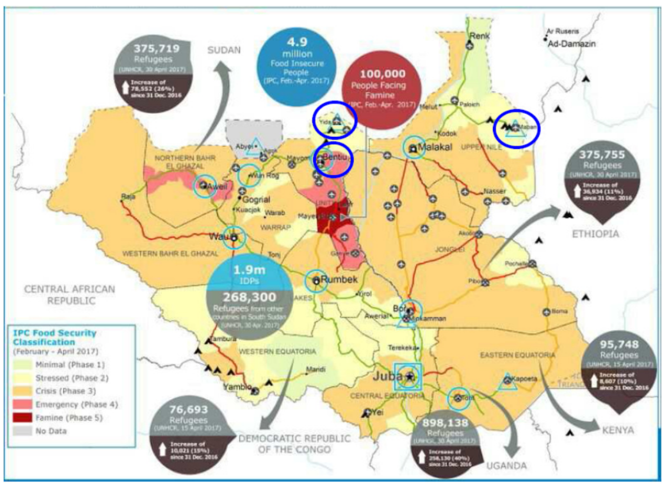
- Base funding decision in costs over life cycle of equipment rather than on capital costs of installations. As much as possible extend funding lines for a period of 2 years or more, so that the use of solar technology can be more strongly supported.
- Consider the possibility to make a more explicit mention on the use of solar water technologies in relevant strategic documents and/or develop a clear framework for the use of solar technology in water supply projects.
- Consider the possibility to support the creation of a focal solar expert at country level to support all WASH actors in the mainstreaming of solar technologies, especially at POCs and camps.

2. Objectives of Mission and Team.

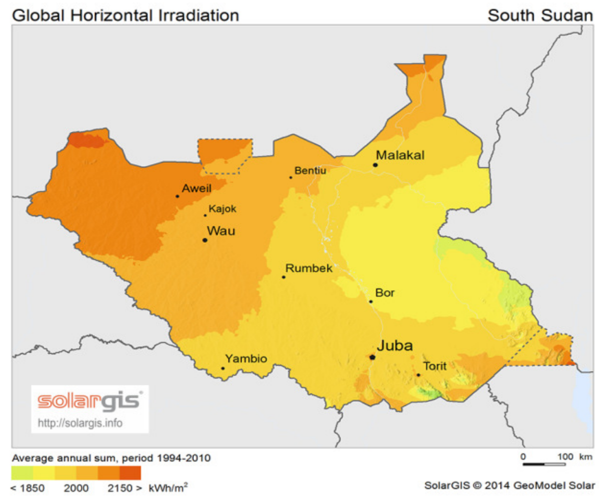
Objectives and terms of reference were drawn and agreed in coordination with the WASH cluster (see Annex B).

3. Selection of Areas Visited.

Bentiu POC camp, Maban IDP camps (3) and Yida, Ajuong Thok and Pamir refugee camps were selected for the visits based on either existence of solar schemes or generator schemes targeted for solarisation. Some targeted sites were not visited due to security and access challenges. All the 7 locations get a high solar radiation through the year, with average of over 6.0 peak sun hours per day.



Map1: Visited locations



Map 2: Average annual Solar Irradiation – 1994-2010

4. Existing Pumping Systems and Proposed Solarization.

Existing motorized boreholes were assessed in the 7 locations mentioned above. Non-optimal sizing of systems especially oversized diesel generators together with undersized and/or wrongly oriented solar PV generators were the most common problem encountered in the field.

It was noticed the lack of water level monitoring in all boreholes visited that linked to the absence of water level sensors resulted in the burning out of several pumps. Some water meters were non-functional indicating a lack of knowledge of demand and system performance. As expected, operating generators remains the biggest challenge due to fuel/oil theft and logistical challenges (insecurity and inaccessibility during rains). Frequent generator failure and replacement is also common.

Population data in areas to be served by high yield motorized boreholes, as well as Safe Yields of boreholes, were largely unknown. In this sense, the solar systems proposed in the table below correspond to the largest possible ones taking as a reference the current water output supplied by generators.

Population figures and hence daily water requirements should be clear before a final design is proposed. In case they are not or it is likely that population increases in the short or medium term, a hybrid system should be favored till a clear understanding of population to be served is gained. Likewise and due to the low O&M available at province level, DC systems have been prioritized over AC, due to their longer lifespan, higher efficiency and robustness.

Table 1: proposed solarizations

Site Details			Pumping Technology		Proposed Pumping System			Water Output			Comment /Recommendation
Camp	BH ID	Managing Agency	Existing System	Proposed System	Proposed Power Pump kW	Propposed Generator power, kVA	Proposed Solar Power Size (Wp)	Daily Water Demand (m3/day)	Average Daily Output Solar (m^3/day)	Daily Output Generator (m^3/day)	
Bentiu	Sector 1 Block 7	Mercy Corps	Generator	Hybrid (Solar + Generator)	2.2	6	4,420	198.3	71.1	127.2	Install solar and supplemet with diesel pumping to meet demand and reduce fuel expenditure. The generator size should also be reduce to 5-6kVA to reduce on fuel expenditure.
Bentiu	Sector 5 Block 8	Concern Worldwide	Generator	Hybrid (Solar + Generator)	9	22	22,100	401.6	151.1	250.5	Current pumping hours are not meeting demand and should be supplemented with solar for 8hrs to meet full demand. The generator size should also be reduce to 22kVA to reduce on fuel expenditure. In order to ensure sufficient presssure at the taps, elevated tank(s) should be installed nearer to the users.
Bentiu	Sector 4 Block 3	Mercy Corps	Generator	Hybrid (Solar + Generator)	7.5	20	15600	291.9	182.0	109.9	Install solar and supplemet with diesel pumping to meet demand and reduce fuel expenditure.
Bentiu	Booster pump for all 6 water schemes	Mercy Corps	Generator	Solar	4.0	12	8320	198.3	220.0	0.0	The existing diesel booster pumps in all boreholes should replaced with solar stand alone. New elevated steel tanks in sector 1,4&5 should be constructed nearer to the users in order to improve efficiency and ensure sufficient pressure at the taps.
Ajuong Thok	Market	Samaritan Purse	Generator	Solar	4	Not needed	10,500	71.0	71.0	0.0	Generator can be replaced by stand alone solar, with high cost effectiveness

Full technical reports for any of the systems proposed I the below table are available upon request at solarquery@iom.int

A table with the main characteristic and recommendations for the **existing mechanized boreholes** is shown below.

Table 2: details and comments on existing solar systems.

Site Details			Existing Pumping System			Water Output			Comment /Recommendation
Camp	BH ID	Managing Agency	Pump model and power	Generator power, kVA	Solar PV power, Wp	Daily Water Demand (m3/day)	Average Daily Output Solar (m^3/day)	Daily Output Generator (m^3/day)	
Pamir	001-BH	Samaritan Purse	Grundfos SP14A-25, 7.5kW	17.1	10,440	180.0	90.0	90.0	Solar system seems well sized
Maban	Gendrassa-BH2	ACTED	Grundfos SP14-17, 4kW	16.0	5,000	Unknown	Unknown	Unknown	Since basic borehole data are unknown, not possible to know whether more could be done with Solar. Generator oversized, changed t+K15o12kVA when possible.
Maban	Gendrassa-BH3	ACTED	Grundfos SQ5-70, 1.85kW	16.5	_	_	_	_	Panels and batteries stolen during clashes, lasted 2 months
Maban	Gendrassa-BH5	ACTED	Grundfos SQ5-70, 1.85kW	13.8	4,800 with 8 batteries 1600AH	Unknown	0.0	45.0	Problem in battery charger. Generator greatly oversized, change to 6kVA when possible.
Maban	Gendrassa-BH9	ACTED	Grundfos SQ5-70, 1.85kW	Taken for repair	4,800 with 8 batteries 1600AH	Unknown	Unknown	Unknown	Battery stolen and replaced, generator not working.
Maban	Gendrassa BH-22	ACTED	Lorentz PS4000-CSJ5-15, 4kW	11.0	1,850	Unknown	Not working	38.0	Solar not working, PS controller not responding. Solar panels are far too little for the given pump, far from maximizing solar water output. Ask for redisgn, upgrade. Solar panels are placed flat, give angle or ensure weekely cleaning.
Maban	Gendrassa BH-29	ACTED	Lorentz PS4000-CSJ5-15, 4kW	11.0	2,340	Unknown	25.0	Unknown	Solar design is wrong with either solar generator power very low for the given pump or pump oversized for the given borehole. Ask for redisgn, upgrade.
Maban	Kaya BH-1	ACTED	SQ5-70, 1.85kW	18.0	6,600	Unknown	Not working	110.0	Grundfos SP14-17 burnt, replaced temprarely by SQ5-70. Generator very oversized. Change back to SP14-17 with solar asap. Stock some SP14-17.
Maban	Kaya BH-2	ACTED	Grundfos SP14-18, 5.5kW	18.0	6,600	Unknown	Not working	154.0	Solar generator disconnected. Unknown problem. Solar panels seem far too little for the given pump. Review design and think of service agreement with solar provider in Juba to service all solar pumps in Maban

Maban	Kaya BH-3	ACTED	SQ5-70, 1.85kW	18.0	6,600	Unknown	Not working	41.0	Grundfos SP14-17 burnt, replaced temprarely by SQ5-70. Generator very oversized. Change back to SP14-17 with solar asap. Solar panels seem far too little for the SP14-17. Review design. Trim trees shadowing solar panels.
Maban	Kaya BH-4	ACTED	Grundfos SP14-18, 5.5kW	18.0	6,600	Unknown	Unknown	Unknown	Trim trees shadowing panels. Since there are no data on Safe Yield or water output or water needs, it is not possible to recommend any design, although the Solar PV generator seems undersized (or pump oversized) which is probably why Solar only works for 6h a day. Even with Solar PV undersized, economic analysis is very favourable to Solar
Maban	Kaya BH-5	ACTED	Lorentz PS4000C, 4kW	11.0	6,600	Unknown	Unknown	Unknown	Original invertor and pump SQ5-70 with batteries got burnt. Replaced by Lorentz PS with PowerPack 4000 installed. Since there are no data on Safe Yield or water output or water needs, it is not possible to recommend any design.
Maban	Kaya-Primary storage	ACTED	Grundfos CR-45 x 2, 22kW	75.0	44,500	Unknown	Not working	Unknown	Solar control panel got burnt 5 months ago, waiting for replacement from Norway. Although pumps are Grundfos, UNHCR chose to use panels that don't exist in the Region, bring no added value and need long lead time for parts, repairs. Replace panels by Grundfos panels to avoid similar situation in the future.
Maban	Doro-Mayak	ACTED	Grundfos SP14-17, 4kW	12.0	5,000	97.0	32.0	65.0	More water could be got with Solar by adding more panels (the solar PV generator is undersized for the given pump and borehole). Review design.
Maban	Doro-New Belila	ACTED	Grundfos SQ5-70, 1.85kW	12.0	4,800	Unknown	Unknown	Unknown	1 battery already had to be replaced within the first 6 months. Generator overesized, change to 6kVA when possible.
Maban	Doro-Old Belila	ACTED	Grundfos SP14-27, 7.5kW	18.0	13,500	123.0	35.0	88.0	Since Safe Yield is unknown, not possible to know whether more could be done with Solar.
Maban	Doro-Penamayu	ACTED	Grundfos SP9A-18, 4kW	12.0	4,250	95.0	41.0	54.0	Since Safe Yield is unknown, not possible to know whether more could be done with Solar.
Maban	Doro-Podum1	ACTED	Grundfos SQ5-70, 1.85kW	_	4,800 + 8 batteries 1600AH	Unknown	35	_	Stand alone solar.
Maban	Doro-Samari	ACTED	Grundfos SP14-17, 4kW	18	5,000	116.0	48.5	67.5	Since Safe Yield is unknown, not possible to know whether more could be done with Solar.
Bentiu	Sector 2 Block 9	IOM	5.5	15	15,600	316.5	197.0	119.5	Solarization is ongoing and design has been confirmed to be coherent.
Bentiu	Sector 3 Block 1	IOM	4	12	10,920	417.1	120.0	224.0	Current borehole cannot meet the demand. There are plans to drill a new borehole in Block 12. solarization is ongoing with 20x3x260W solar modules initially meant for a 5.5kW pump which could not fit into the borehole. Reduce the panels to 21x2x260W and the remainder can be used elsewhere. Change genset to 10kVA to reduce on fuel expenditure.

Full technical reports for any of the systems proposed I the below table are available upon request at solarquery@iom.int

5. Economic analysis.

A Present Worth methodology to compare costs over life cycle of different technology options was used, in order to better inform decisions when it comes to motorizing boreholes. Prices used for this analysis were averaged from real quotations shared by implementing agencies and estimations taken from existing reports on costs of repairs and maintenance of generators. Details of methodology can be found in Annex A.

An economic analysis was done comparing the existing diesel systems with the proposed solar stand-alone or hybrid ones (see table below), showing an average breakeven point for solar investment of only 1.4 year, which is short, and so very favorable to Solar schemes. The average reduction of expenses in installation and O&M cost was estimated at -53%. In other words, existing generators powered water schemes are costing more than double their solar/hybrid equivalents.

Table 3: economic comparison of existing generator systems vs proposed solar or hybrid systems.

Site Details			Pumping Technology		Water Output			Economic/Life Cycle Analysis					
								Generator stand alone		Hybrid or Solar		Hybrid/Solar vs Generator	
Camp	BH ID	Managing Agency	Existing System	Proposed System	Average Daily Output of Proposed Solar (m^3/day)	Daily Output of Proposed Generator to work with Solar, m3/d	Daily Output of current Generator (m^3/day)	Initial cost (USD)	Cost over Life Cycle (USD)	Initial cost (USD)	Cost over Life Cycle (USD)	Reduction of expenses Hybrid/Solar vs Genset	Break-even point
Ajuong Thok	Market	Samaritan Purse	Generator	Solar	72	0	72	$0	$255,781	$21,500	$34,515	-87%	0.7 years
Bentiu	Sector 1 Block 7	Mercy Corps	Generator	Hybrid (Solar +Generator)	71	127	198	$0	$357,069	$13,300	$238,983	-33%	0.7 years
Bentiu	Sector 4 Block 3	Mercy Corps	Generator	Hybrid (Solar +Generator)	0	110	110	$0	$255,095	$36,069	$148,211	-42%	2.2 years
Bentiu	Sector 5 Block 8	Concern Worldwide	Generator	Hybrid (Solar +Generator)	0	250	250	$0	$962,818	$44,907	$656,393	-32%	1.0 years
Bentiu	Booster pump for all 6 water schemes	Mercy Corps	Generator	Solar	197	0	197	$0	$169,463	$45,099	$54,469	-68%	2.5 years

Full economic analysis report for any of the systems in the above table is available upon request at solarquery@iom.int

As it is normally the case, stand alone solar systems have in general shorter breakeven periods and higher reduction in costs % when compared to equivalent diesel generators ones. Larger hybrid (solar+diesel) have, when compared to stand alone generator systems, longer breakeven periods and lower reduction cost in %, although net reduction costs are higher.

Table 4: economic comparison of existing solarized systems vs their equivalent generator ones.

Site Details			Water Output			Economic/Life Cycle Analysis					
						Generator stand alone		Solar stand alone or Hybrid		Hybrid/Solar vs Generator	
Camp	BH ID	Managing Agency	Average DailyOutput Solar (m^3/day)	Daily Output Generator (m^3/day)	Combined Daily Output (m3/day)	Initial cost (USD)	Cost over Life Cycle (USD)	Initial cost (USD)	Cost over Life Cycle (USD)	Reduction of expenses Hybrid/Solar vs Genset	Break-even point
Maban - Kaya	BH 4	ACTED	Unknown -but 6h of pumping-	Unknown -but 10h of pumping	Unknown	0	219,659	25,400	175,422	-20%	2.4 years
Maban-Doro	Mayak	ACTED	32	65	97	0	159,322	18,760	137,086	-14%	4.4 years
Maban-Doro	Old Belila	ACTED	35	88	123	0	250,003	37,900	189,185	-24%	3.5 years
Maban-Doro	Penamayu	ACTED	41	54	95	0	186,259	17,200	135,526	-27%	2.0 years
Maban-Doro	Samari	ACTED	49	68	116	0	276,687	23,100	158,957	-43%	1.3 years
Ajuong Thok	UN	Samaritan Purse	40	0	40	0	112,259	11,700	24,715	-78%	0.9 years
Ajuong Thok	Open Space-block 21	Samaritan Purse	44	70	114	0	418,449	32,500	301,296	-28%	1.9 years
Pamir	001-BH	Samaritan Purse	90	90	180	0	376,965	25,500	225,321	-40%	1.1 years
Bentiu	Sector 2 Block 9	IOM	120.0	119.5	239.5	0	261,291	32,747	147,790	-43%	1.4 years
Bentiu	Sector 3 Block 1	IOM	151.1	224.0	375.1	0	439,489	23,998	322,798	-27%	1.2 years

Full economic analysis report for any of the systems in the above table is available upon request at solarquery@iom.int

The above table shows a break-even point (or return-on-investment) of 2.0 years and an average cost reduction of -35%. 5 systems had already their capital costs paid back, showing a high cost-effectiveness of investment.

6. Final technical observations.

Low solar technical competence is the main obstacle towards a successful solarization of existing boreholes and organizations including UNHCR & UNHCR, as the leading coordinating WASH agencies in the country should discuss on options available at country level to close this gap.

Chlorination (especially in-line) should be standard in any mechanized borehole whether it is powered with solar or not. The size of the tanks for solar schemes (whether stand alone or hybrid) need attention, as normally solar schemes will require larger tanks in order to store as much water as possible during sun hours, even though the demand might be low at that time.

Solar technology beyond water pumping: with the high and constant solar radiation in South Sudan through the year, solar products for lighting and general powering should be given a higher consideration, especially at institutions, offices or compound level, where the constant presence of humanitarian organizations can facilitate the O&M of the systems.

The solar initiative aims to support organizations willing to go solar and it that regard, a technical helpline is open and freely available up to April-2018 at solarquery@iom.int

7. Summary of next agreed steps.

- Use of tools and documents provided during training to gauge solar opportunities for existing and future boreholes.
- Internal discussion at organizational level for establishing a technical group, coordinate the solar agenda.
- Naming of 2 solar contact focal people in the country that will be invited by the Solar Initiative to get further training, bring it back to South Sudan.
- Further 1-week training will be available at Energy Research Center in Strathmore University, Kenya, through RedR and on-line. The solar team will share dates and details as they are made public.

End.