Visit Report – Solar and Water Initiative

IDP settlements in Darfur, Sudan – 20th February to 18th March 2017

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1 - EXECUTIVE SUMMARY and RECOMMENDATIONS.

A 4 week visit took place in Sudan in order to assess a number of existing solar pumping schemes, evaluate the feasibility to solarize new water points in a few selected IDP camps and host communities, and raise awareness and solar technical expertise among WASH stakeholders in the country.

Due to delayed travel permits, only 4 IDP camps were visited in North and South Darfur. Selection of visited sites was determined by the presence of solar schemes or high yielding boreholes not solarized and security and logistic constraints.

In total 22 high yielding boreholes were assessed, with 19 running on diesel generators at the moment of the visit and 3 solarized for which there were either not enough data available to do a study or were not functioning. The impossibility to get travel permits on time and the numerous procedures to be followed while in the field, cut short visit to other camps in Darfur and stopped the visit to Easter Sudan. Therefore there might be more boreholes (both solarized and generator based) within the areas visited. However it is believed that the conclusions of current report could apply to several other areas.

Climatological and hydrogeological conditions in the sites visited were favorable, making the use of solar pumping a technically feasible solution for each and every of the boreholes assessed.

Decreasing trend of solar product prices, no taxation of imported solar panels, technical expertise available at private sector level in Khartoum, support from Sudan Water Ministry and other international organizations of solar pumping in their strategic plans/ policy frameworks and the wider support and priorization given by some donors to solar solutions in Sudan, together with an exceptionally high solar radiation through the year in most of the country make the context in principle good to use of solar pumping in the areas visited and beyond.

Others enabling factors are summarized in the following table:

CLIMATE & HYDROGEOLOGY All boreholes analysed conducive to be solarized	**SOLAR PRICES** Decreasing prices, some government policies exempting taxes on solar products	**NATIONAL TECHNICAL EXPERTISE** Available at Private Sector at capital level.
INVESTMENT IN SOLAR Solar pumping not new in Sudan, some hundreds of solar water points recorded	**RELIABILITY OF TECHNOLOGY** Presence of high quality products in country market	**POLICY** Government favorable to solar pumping, funds available

The absence of parts and maintenance service in most of rural Sudan together with issues to do with theft and harsh environmental conditions [especially in the North] are factors that however play against solar and should prompt a case by case context analysis for the implementing organizations.

On existing generator powered boreholes:

A visit to 19 generator powered boreholes -with proper data recorded by the implementing NGOs- was carried out in the 4 camps visited. Recommendations were produced to motorize them all with either small or medium-sized solar stand-alone or solar-diesel hybrid systems, *able to jointly supply 937m3/d or water for 62,400 people* (or up to 1,600 m3/d for 107,000 people if pumping time of generators of hybrid solar-diesel schemes were to be extended during the night).

Recommendations were based among others on population data provided during the visits, which were reported to be inaccurate. ***A general recommendations is made to use solar-diesel hybrid systems –as opposed to stand alone solar ones- there where population figures are not well known or can significantly increase in the short term, when the behavior 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 prioritize as they are the most cost effective solutions and the payback period of the investment cost is shorter. Besides, 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**.

Stand-alone solar systems in boreholes with safe yields of less than 1.5 m3/h make little sense as they would offer little advantage against a simple handpump. In those situations hybrid (diesel-solar or handpump-solar) are better options to be explored.

Besides, all the solar conversions recommended but 3, propose the use of DC systems, that are simpler, robust, cost-effective and have longer lifespans; these should be favor over AC when possible and till more evidence on the suitability of AC systems is collected for the Sudanese context.

From the economic point of view, an analysis over the life cycle of the equipment was carried out by bringing all estimated costs to a present worth. As the financial and inflation rates have not been made public by the Sudanese Central Bank for some years, an approximation was used based in the last information available dating from 2008 (details of methodology in annex A).

An economic analysis was run comparing the proposed solar/ hybrid systems with stand-alone generator ones. The initial capital cost of solarizing 20 boreholes is estimated to be a total of 2.7 million SDG or 140,000 SDG more expensive than the capital cost of installing diesel-generators (cost of pumping equipment up to the borehole outlet). **Said in other words, on average, solar capital cost is 140,000SDG higher per water point**. The analysis also shows an ***average breakeven point for the solar investment of 3.7 years, and an average reduction of overall expenses (capital costs plus all the others) of -55%. Said in a different way, overall cost of the solar systems proposed are less than half of their equivalent diesel generator ones.*** This also shows that even for a country where diesel prices are very low, solar technology still can make economic sense.

As such**, if context analysis shows, as it seems to be, that IDP camps will be open for more than 3 to 4 years, extensive use of solar energy at water points is the way forward**, there where security of equipment and its maintenance can be warranted, and especially if fuel supply is erratic.

For new IDPs sites, ***there is no need to wait for long years to move into more sustainable and cost effective technology solutions when the appropriate conditions and technical expertise are in place***.

<u>On existing solar boreholes:</u>

Solar water schemes have been implemented in Sudan since at least 2005, with over 200 solar pumping schemes installed in the country (mostly Darfur IDP camps and rural communities). However only 3 solar pumping schemes could be visited due to delayed travel permits: 1 with an issue in the control box was reverted to generator scheme and 2 with the managing NGO unable to provide sufficient data on the system and borehole to do any study.

The combined low solar technical expertise encountered among humanitarian WASH staff and lack of after sale support properly established beforehand might explain these problems.

<u>Other issues:</u>

The single most important barrier towards a successful solarization of water points in the camps and host communities is the low solar technical expertise of most of WASH stakeholders involved in water supply projects. In this sense, a 3-day training was conducted in Khartoum, counting with the presence of most of the major WASH actors of the areas visited and government water technicians coming from 9 different provinces. Tools, documents and contacts for remote 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, taking advantage of the knowledge already present at Khartoum level and widening and adapting the scope of these trainings to address real problems encountered in the field.

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).

Depleting water levels and over pumping of some boreholes is an issue of great importance in some areas visited and monitoring and interpretation of both water level and abstraction rates should be reinforced, as this was weak or absent in almost all boreholes assessed; this is the only way to anticipate drying up of boreholes. ***While solar technologies are not a solutions for depleting aquifers, they offer the possibility to daily remotely monitor and record water levels*** in a very easy way. The use of remote monitoring is therefore recommended especially for critical and/or distant boreholes, till the moment when a sound understanding of the aquifer exploited is gained.

Besides, 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 sale support is important especially from the first 18-24 months to ensure long lasting solar schemes. Supporting technology alone is not a recommended approach since social 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 paramount importance, as most likely communities won't be able to solve certain problems on their own, even if trained. In this sense, favoring the more robust DC solar schemes and coordinating approaches with government water offices should be a pre-requisite for this kind of projects.

Finally, the use and presence of under quality panels and inverters in the Sudanese private market underline the importance of having ***a clear idea of what is a good and bad quality product, which should be entrusted among partners***, since the use of solar technology makes more sense when thinking in medium and long term.

This combined with efforts to evaluate and capitalize on the existing solar schemes in the country, work around creating/ improving guiding solar documentation and recurrent refreshment capacity building of WASH staff should lay the foundation for the expansion of solar technology in water supply projects in Sudan, since the technology is a no brainer, the environmental conditions are very appropriate, the technology is well accepted by users and beneficiaries and WES and some donors are favorable to the use of solar pumping at a wider scale.

Recommendations:

For implementing organizations:

- Build/ seek for technical capacity in order to know what designs, products and layouts are the best suited for every water point.

- Ensure after sale support service for the first 18-24 months after installation in a contract at the time of tendering or purchase. Favor 1-supplier policy to ensure warranties are kept in case of problems.

- Ensure proper pumping test and regular monitoring of water levels considering the possibility of using remote monitoring technologies. Additionally ensure chlorination of water and right tank sizing in all solar schemes at camp level.

- When working at community level, get to know existing government approach and models and involve corresponding government technical offices from the beginning. Whenever possible, prioritize areas where DC solar systems can meet the demand since they are more simple, economic and robust than AC systems.

For coordinating organizations:

- Reinforce inter-agency collaboration among implementing/ operating partners, in order to build up internal technical capacity. Use expertise available at country level (experienced NGOs and private sector) to organize regular refreshment 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, among others, to improve the proposed Solar pumping guidelines through evaluation of existing solar schemes and collection of lessons learnt and best practices in Sudan, which would serve as a reference for good practice for all actors involved.

- Assess different modalities for buying solar panels in bulk (at country level or through regional offices). Entrust identification and use of quality products since solar makes more sense in the medium and long term.

- Assess the possibility to support/ promote a solar training center at Khartoum University/ WES training center or other, similar to the one existing in Nairobi, that would serve as a reference for regular training of both government, NGO, UN technical staff as well as for private sector actors.

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.

- Support the use of solar pumping technology at IDP camp level, including evaluation of actions and further building up of evidence on suitability of solar pumping for the given contexts.

2 - OBJECTIVES OF THE MISSION AND TEAM.

Terms of reference were drawn and agreed in coordination with IOM Sudan and the WASH coordination group and are shown in Annex B. All goals of the mission were achieved, except for the visit to a higher number of solar schemes, both in Darfur and Easter Sudan, due to delayed travel permits.

3 – SELECTION OF AREAS VISITED.

4 long-term established IDP Camps located in North and South Darfur were visited (El Salam, Abu Shouk, Zam Zam and Kalma). Camps were selected in terms of existing solar schemes or generator schemes prone to solarization. Travel permits were granted only to visit those in the proximity to provincial capitals in order to minimize security risks. All of 4 camps get a high solar radiation through the year, with average of over 6.3 peak sun hours per day.

4 – EXISTING PUMPING SYSTEMS AND PROPOSED SOLARIZATION.

Existing motorized boreholes were assessed in the 4 camps mentioned above. Non-optimal sizing of systems (undersized or oversize pumps and oversized generators) was the most common problem encountered. Besides, it was noticed the lack of water level monitoring in all boreholes visited. Reinforcing this monitoring is the only way to anticipate the problem of depleting aquifers and drying up of water points.

The recommendations made in the table below were produced to motorize all boreholes but 3 (where data are missing) with either solar stand-alone or solar-diesel hybrid systems, ***able to jointly supply 937m3/d or water for 62,400 people*** (or up to 1,600 m3/d for 107,000 people if pumping time of generators of hybrid solar-diesel schemes were to be extended during the night).

Population data in areas to be served by high yield motorized boreholes, were sometimes unknown. In this sense, the solar systems proposed in the table below correspond to the largest possible ones given the limitation of the stated safe yield (75% of this value). 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 solar systems for existing generator-based boreholes.

Site Details				Technical Design							Priority of recommendation
No.	Camp	BH ID	Managing Agency	Proposed Power Pump kW	Proposed Solar Power Size	Daily Water Demand (m3/day)	Daily Output Solar (m^3/day) in month with least output	Daily Output Generator (m^3/day)	Combined Daily Output (m3/day)	Comment /Recommendation	
1	El Salam	BH1 Halouf	Oxfam	4,0	6750	56,0	51,0	5,0	56,0	Change to DC pump and operate on hybrid solar-diesel to meet demand	Medium
2	El Salam	BH2 Zaki	Oxfam	4,0	5250	74,1	47,0	27,1	74,1	Change to DC pump and operate on hybrid solar-diesel to meet demand	High
3	El Salam	BH3 Abdikeir	Oxfam	0,7	1500	16,0	16,0	0,0	16,0	Change to stand alone DC pump to meet demand	High
4	El Salam	BH4 Mahadi	Oxfam	4,0	6750	65,6	49,0	16,6	65,6	Change to DC pump and operate on hybrid solar-diesel to meet demand	High
5	Abu Shouk	BH1 Zakaria	WES	4,0	3500	42,0	41,0	0,0	41,0	Change to stand alone DC pump to meet demand	Medium
6	Abu Shouk	BH2	WES	4,0	4000	42,0	43,0	0,0	43,0	Change to stand alone DC pump to meet demand	Medium
7	Abu Shouk	BH4 - ICRC	WES	4,0	3500	45,0	46,0	0,0	46,0	Change to stand alone DC pump to meet demand. Note this site had a solar system which broke down and they reverted to generator.Existing solar modules (8no) can be used on new pump.	Medium
8	Abu Shouk	BH5 Wadi	WES	5,5	7800	63,0	42,0	21,0	63,0	Change to AC solar pump and operate on hybrid solar-diesel to meet demand	Medium
9	Zamzam	BH1 Salouma	WES	1,7	2500	25,0	5,5	19,5	25,0	The borehole yield is too low to make economic sense for solar. Consider drilling a new borehole as it is not meeting the demand	N/A
10	Zamzam	BH2 Elfaib	WES	1,7	3000	70,0	37,0	33,0	70,0	Change to DC pump and operate on hybrid solar-diesel to meet demand. Change generator to 5kVA in order to reduce fuel cost	High
11	Zamzam	BH3 Abdalla	WES	1,7	2000	60,0	23,0	37,0	60,0	Change to DC pump and operate on hybrid solar-diesel to meet demand. Change generator to 5kVA in order to reduce fuel cost	High
12	Zamzam	BH4 ZZA	WES	1,7	2000	25,0	24,0	0,0	24,0	Change to stand alone DC pump to meet demand. Change generator to 5kVA in order to reduce fuel cost	High
13	Zamzam	Elsalam School	WES	1,7	1560	25,0	26,0	0,0	26,0	There is an existing solar pump whose details and performance are unknown. If new solar pump is installed it has the capacity to meet demand via stand alone solar.	N/A
14	Kalma	Al Haj Osman Haroon	Oxfam	4,0	4500	72,0	42,0	30,0	72,0	Change to DC pump and operate on hybrid solar-diesel to meet demand	Medium
15	Kalma	Mohammed Yousef Mohammed	Oxfam	1,7	3000	60,0	36,0	24,0	60,0	Change to DC pump and operate on hybrid solar-diesel to meet demand. Change generator to 5kVA in order to reduce fuel cost	High
16	Kalma	Abaker Abdel Karim Abaker	Oxfam	1,7	3000	36,0	36,0	0,0	36,0	Change to stand alone DC pump to meet demand. Change generator to 5kVA in order to reduce fuel cost	High
17	Kalma	Mahmoud Adam Ali	Oxfam	4,0	4095	84,0	41,0	43,0	84,0	Change to DC pump and operate on hybrid solar-diesel to meet demand.	Medium
18	Kalma	Mahmoud Adam Ali -	Oxfam	5,5	11000	84,0	84,0	0,0	84,0	Change to AC stand alone solar pump to meet demand	Low
19	Kalma	Abdurhman Ahmed	Oxfam	4,0	4000	75,0	54,0	21,0	75,0	Change to DC pump and operate on hybrid solar-diesel to meet demand	High
20	Kalma	Ahmed Zakaria Adam	Oxfam	4,0	5250	56,0	55,0	0,0	55,0	Change to stand alone DC pump to meet demand	Medium
21	Kalma	Ahmed Zakaria Adam -	Oxfam	5,5	9360	56,0	69,0	0,0	69,0	Change to AC stand alone solar pump to meet demand	Low
22	Kalma	Ibrahim	Oxfam	0,0	125W x 18	0,0	0,0	0,0	0,0	Full borehole and site details not available for analysis to be done	N/A

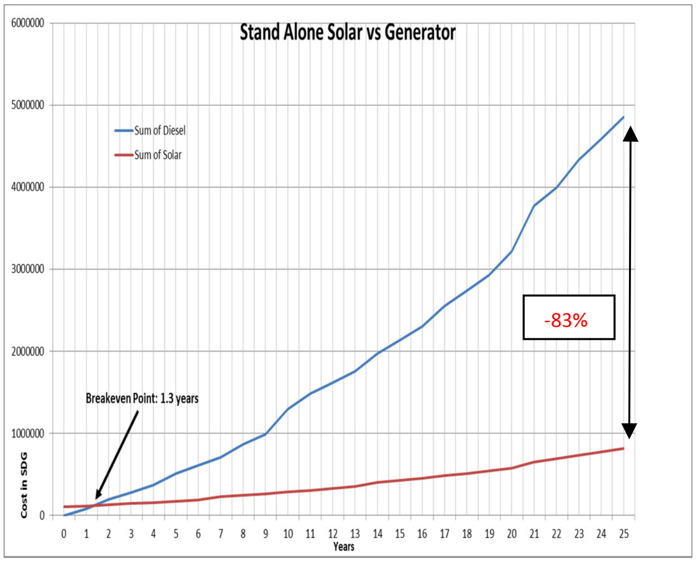
Full technical reports for any of the systems proposed I the below table are available upon request at solarquery@iom.int

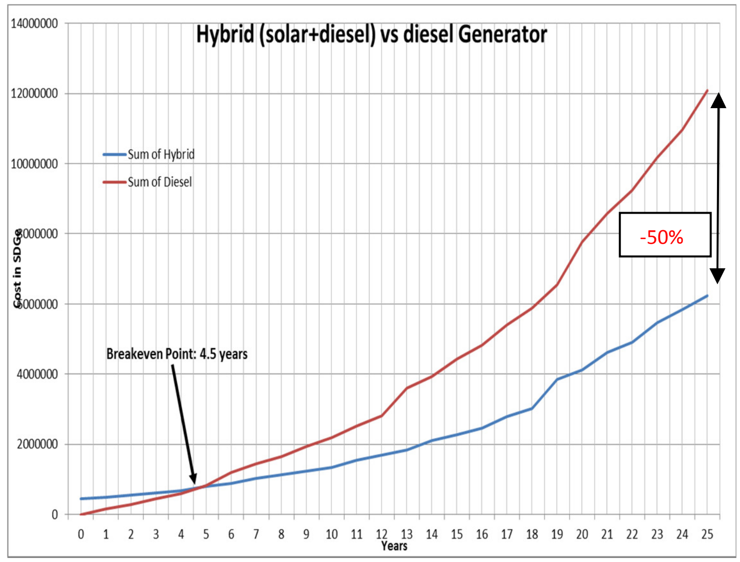
6- ECONOMIC ANALYSIS.

An agreed methodology was used to compare costs over life cycle of the proposed solarised systems versus the existing generator systems, 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 run comparing the proposed solar/ hybrid systems with stand-alone generator ones in order to find the breakeven point of the solar investment as well as the reduction of expenses over the life time of the equipment (see it visualized in the below graphic for 2 of the systems proposed).

Graph 1 : Cumulative cost over life of equipment of 2 of the studied systems.





As it is normally the case, the example graphs also show that stand alone solar systems have in general shorter breakeven periods and higher reduction 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.

The initial capital cost of solarizing 20 boreholes is estimated to be a total of 2.7 million SDG or 140,000 SDG more expensive than the capital cost of installing diesel-generators (cost of pumping equipment up to the borehole outlet). Said in other words, on average, solar capital cost is 140,000SDG higher per water point. The analysis also shows an *average breakeven point for the solar investment of 3.7 years, and an average reduction of overall expenses (capital costs plus all the others) of -55%.*

Table 2: Economic comparison of proposed solar systems vs existing generator systems.

Site Details				Water Output of Prposed Systems (hybrid or solar)			Economic/Life Cycle Analysis					
							Exisitng Generator stand alone		Proposed Hybrid or Solar stand alone		Hybrid/Solar - Diesel Comparison	
No.	Camp	BH ID	Managing Agency	Daily Output Solar (m^3/day) in month with least output	Daily Output Generator (m^3/day)	Combine d Daily Output (m3/day)	Initial cost (SDG)	Cost over Life Cycle (SDG)	Initial cost (SDG)	Cost over Life Cycle (SDG)	Reduction of expenses Hybrid/Solar vs Genset	Break-even point
1	El Salam	BH1 Halouf	Oxfam	51,0	5,0	56,0	84.551	4.734.916	277.499	1.266.550	-73%	4.0 years
2	El Salam	BH2 Zaki	Oxfam	47,0	27,1	74,1	78.441	6.919.470	236.769	3.633.312	-47%	2.8 years
3	El Salam	BH3 Abdikeir	Oxfam	16,0	0,0	16,0	39.042	4.775.302	82.945	792.953	-83%	1.2 years
4	El Salam	BH4 Mahadi	Oxfam	49,0	16,6	65,6	84.060	8.102.259	277.008	2.843.084	-65%	2.5 years
5	Abu Shouk	BH1 Zakaria	WES	41,0	0,0	41,0	84.060	2.791.893	201.999	1.065.732	-62%	4.6 years
6	Abu Shouk	BH2	WES	43,0	0,0	43,0	86.633	3.148.846	216.112	1.079.846	-66%	4.0 years
7	Abu Shouk	BH4 - ICRC	WES	46,0	0,0	46,0	88.673	3.351.801	206.612	1.070.346	-68%	4.0 years
8	Abu Shouk	BH5 Wadi	WES	42,0	21,0	63,0	96.100	5.137.390	335.427	3.087.197	-40%	5.5 years
9	Zamzam	BH1 Salouma	WES	5,5	19,5	25,0	52.574	Not enough information	135.811	Not enough information	Not enough information	Not enough information
10	Zamzam	BH2 Elfaib	WES	37,0	33,0	70,0	52.139	6.584.106	145.607	3.882.298	-41%	1.5 years
11	Zamzam	BH3 Abdalla	WES	23,0	37,0	60,0	52.812	7.602.515	125.818	4.384.196	-42%	1.0 years
12	Zamzam	BH4 ZZA	WES	24,0	0,0	24,0	50.557	3.184.261	123.563	954.712	-70%	1.7 years
13	Zamzam	Elsalam School	WES	26,0	0,0	26,0	46.131	2.699.250	110.134	941.283	-65%	1.6 years
14	Kalma	Al Haj Osman Haroon	Oxfam	42,0	30,0	72,0	72.873	4.826.304	213.891	3.209.761	-33%	5.3 years
15	Kalma	Mohammed Yousef	Oxfam	36,0	24,0	60,0	31.239	3.603.582	124.707	2.375.555	-34%	2.5 years
16	Kalma	Abaker Abdel Karim Abaker	Oxfam	36,0	0,0	36,0	31.239	2.604.545	124.707	955.856	-63%	2.3 years
17	Kalma	Mahmoud Adam Ali	Oxfam	41,0	43,0	84,0	64.793	4.273.527	196.465	3.128.972	-27%	5.4 years
18	Kalma	Mahmoud Adam Ali - Booster	Oxfam	84,0	0,0	84,0	62.290	3.103.228	372.968	1.418.034	-54%	9.7 years
19	Kalma	Abdurhman Ahmed Suliman	Oxfam	54,0	21,0	75,0	64.344	5.000.901	193.823	2.365.203	-53%	3.0 years
20	Kalma	Ahmed Zakaria Adam	Oxfam	55,0	0,0	55,0	63.895	3.184.345	222.223	1.085.957	-66%	4.5 years
21	Kalma	Ahmed Zakaria Adam - Booster	Oxfam	69,0	0,0	69,0	62.290	2.328.102	336.401	1.381.466	-41%	11.3 years
22	Kalma	Ibrahim	Oxfam	0,0	0,0	0,0	Not enough information	Not enough information	Not enough information	Not enough information	Not enough information	Not enough information

Full economic analysis report for any of the systems in the 2 below tables are available upon request at solarquery@iom.int

7 - FINAL OBSERVATIONS.

Low solar technical competence is the main obstacle towards a successful solarization of existing boreholes and organization. It is strongly believed that UNICEF together with WES, as the leading coordinating WASH agencies in the country, should take the lead to discuss on options available at country level and beyond to close this gap.

Chlorination (especially on-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, in order to have stored water to supply during non-sun hours.

Solar technology beyond water pumping: with the high and constant solar radiation in Sudan through the year, it is remarkable the low presence of other solar products for lighting, heating, cooling and general powering as opposed to other countries in the Region, especially for off grid areas or where grid is unreliable.

The solar initiative aim 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

8 – NEXT RECOMMENDED STEPS.

- Use of tools and documents provided during training and the technical helpline to gauge solar opportunities for existing and future boreholes.

-Internal discussion at organizational level for establishing a technical group, coordinate the solar agenda.

-Further 1-week training will be available at Energy Research Center in Strathmore University, Kenya. The solar team will share dates and details as they are made public.