Visit Report – Solar and Water Initiative.

Refugee settlements in Northern Uganda.

10th January to 6th February 2017

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1 - EXECUTIVE SUMMARY and RECOMMENDATIONS.

A 4 week visit took place in Uganda in order to assess a number existing solar pumping schemes, evaluate the feasibility to solarize new water points in refugee settlements and raise awareness and solar technical expertise among WASH stakeholders in the country.

12 refugee settlements were visited in 5 different locations (Kyriandongo, Adjumani, Moyo, Yumbe and Arua). Selection of visited sites was made in function of presence of solar schemes or high yielding boreholes not solarized.

In total 48 high yielding boreholes were assessed, with 16 already solarized at the moment of the visit (all but 3 in the older settlements of Kyriandongo, Adjumani and Arua), 25 yet to be equipped and 7 for which there were not enough data available to make any study. The lack of a working centralized data management system for water points represented a major challenge for the visit. Therefore there might be more boreholes (both solarized and high yielding not mechanized) within the areas visited. However it is believed that the conclusions of current report could apply to all high yielding boreholes of the 5 areas.

Climatological and hydrogeological conditions in all areas 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 Kampala, inclusion of Uganda Water Ministry and UNHCR of solar pumping in their strategic plans/ policy frameworks and the wider support and priorization given by World Bank and other donors to solar solutions in Uganda make the context ideal to mainstream the 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 (213m3/d, 123m depth)	**SOLAR PRICES** Decreasing prices, some government policies exempting taxes on solar products	**NATIONAL TECHNICAL EXPERTISE** Available at Private Sector at capital level. 1-2 NGOs with in-house full technical capacity.
INVESTMENT IN SOLAR Solar pumping not new in Uganda, some '00's of solar water points recorded	**RELIABILITY OF TECHNOLOGY** Presence of high quality products in country market	**POLICY/ GUIDELINES** Government favorable (NDP allocations), existing national guidelines

On non-equipped high yielding boreholes:

A visit to all high yielding non-equipped boreholes -with proper data recorded by the implementing NGOs- was carried out in all the settlements of the 5 areas visited, which amounts for 25 boreholes. Recommendations were produced to motorize them all with either solar stand-alone or solar-diesel hybrid systems, ***able to jointly supply 2,550m3/d or water for 170,000 people*** (or up to 6,050 m3/d for 403,000 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, especially for some areas in the new settlements of Palolinya and Bidibidi. ***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 or when the behavior of the exploited aquifer remains largely unknown***.

Otherwise, and when 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 high yielding 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.

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, using the average of last 5 years real interest rates published by the World Bank for Uganda (details of methodology in annex A).

An economic analysis was run comparing the proposed solar systems with generator stand-alone ones. The initial capital cost of solarizing 23 boreholes is estimated to be a total of 1.3 million USD or 460,000 USD 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 20,000USD higher per water point**. The analysis also shows an ***average breakeven point for the solar investment of only 1.1 years, and an average reduction of overall expenses (capital***

costs plus all the others) of -66%. Said in a different way, overall cost of the solar systems proposed are 1/3 of their equivalent diesel generator ones.

As such**, if context analysis shows, as it seems to be, that refuge settlements will be open for more than 1.5 to 2 years, extensive use of solar energy at water points is the way forward**. Taking into account the ongoing water trucking operation involving some 90 trucks and costing around 400,000 USD/ month, it is easy to see how beneficial it would be to move into solarization of those boreholes at the earliest possible time.

If the implementation of the solar schemes recommended for Bidibidi and Palolinya were carried out, it would be the first time ever this technology is used at scale at an early stage of a refugee crisis and would show, if well managed, that ***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***.

On existing solar schemes:

Solar water schemes have been implemented in Uganda refugee settlements since early 2014, with the majority of the existing systems being handed over from the implementing organization to the currently managing one. This might partially explain the fact that ***after sale support*** - important for solar schemes especially in the first 18-24 months after installation- ***is weak or inexistent***.

This combined with the ***low solar technical expertise among most of field staff*** are at the origin of the problems encountered in 6 of the 16 existing solar schemes, such as:

- abandoning the solar scheme and reverting to generators when solar encounters the first technical problem (2 solar schemes managed by LWF in Adjumani),
- undersized or underperforming solar system that is not checked out for years (1 solar scheme managed by DRC in Kyriandongo) or
- use of stand-alone solar systems in areas where these cannot meet the water demand (some Malteser systems in Arua).

The weak technical guidance and monitoring on these NGOs by government and UNHCR in the field contributed to the mismanagement of these solar schemes. ***Water Missions stands out as the NGO with enough in-house expertise*** to independently design, O&M solar water schemes, and are also the only ones chlorinating water in all of their solar schemes. Strong solar expertise is also available at private sector level in Kampala.

Buying different products at different suppliers and calling someone else for the installation is a procedure used by some organizations in order to save costs, without taking into account that no one would respond to product warranty if problems arise. Likewise the use of under quality panels and inverters was noticed in a few solar schemes and ***a clear idea of what is a good and bad quality product should be entrusted among partners*** in order to make solar water schemes last long.

A similar economic analysis was run for these existing solar systems, showing an ***average breakeven point*** for the solar investment vs stand-alone generator ***of 2.6 years***, which is short –and so, very favorable to Solar schemes- when compared to other countries in the Region. ***The average reduction of expenses in installation, O&M costs was estimated at -40%***. The capital and running costs of 8 hybrid systems in Kyriandongo, Adjumani and Arua have already being recovered. Another 5 hybrid systems are between 2 and 4.5 years to break even, while the remaining 3 were out of order and so, data were not available to make any economic estimation.

On the usual commented issue of ***theft of solar panels***, it was observed that measures taken by NGOs (fencing of compounds, guards in isolated water points and sometimes raising of panels and welding them to frames) are working well. The only case of panel theft recorded during the visit was for a small isolated water pumping station in Alere settlement, whose management was unclear.

Other issues:

The single most important barrier towards a successful solarization of water points in the settlements visited is the low solar technical expertise of most of WASH stakeholders involved in the refugee response, including UNHCR (again with the exception of Water Missions). In this sense, a 2-day training was conducted in Kampala, counting with the presence of most of major WASH actors of the areas visited. 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 Uganda level and widening and adapting the scope of these trainings to address real problems encountered in the field.

Besides, ***the use of good quality products with right quality certifications is strongly encouraged***, since solar technology makes more sense when thinking in the medium and long term. 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 drying up of some boreholes is an issue of great importance in all 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 and it 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.

Finally, some partners expressed the willingness to introduce solar pumping at local community level. While technical solar pumping offers similar advantages as in settlements, 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***. 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, coordinating approaches with government water offices should be a pre-requisite for this kind of projects. Boreholes with both, handpumps and solar pumping systems at once have been introduced in some communities in Uganda and it would be worth further exploring the suitability of this solutions for rural communities in the country.

Recommendations:

For implementing organizations:

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

- 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 refugee settlement level.

- When working at community level (either rural or urban hosting refugee towns), get to know existing government approach and models and involve corresponding government technical offices from the beginning, so that this can be easily handed over to government offices in the future.

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 work to produce/ disseminate Uganda solar pumping guidelines that would serve as a reference for good practice for all actors involved.

- Ensure proper and consistent recording and availability of water point data, including supervision of siting and construction of boreholes.

- 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.

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.

- Assess the possibility to support/ promote a solar training center at Kampala University, as 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.

- Consider the possibility to make a more explicit mention on the use of solar water technologies in the ReHOPE and other relevant strategic documents and/or have a clear framework for the use of solar technology in water supply projects.

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

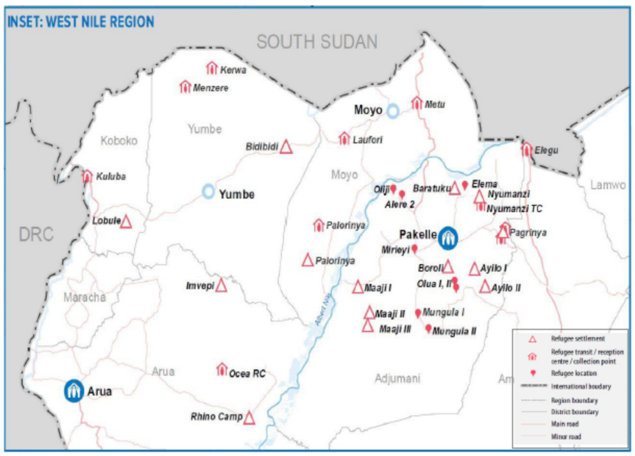
2 - OBJECTIVES OF THE MISSION AND TEAM.

Terms of reference were drawn and agreed in coordination with UNHCR Uganda team and are shown in Annex B. All goals of the mission were achieved, except the visit to Rwamanja settlement. A second visit to the South West including this and other settlements was agreed during the visit with UNHCR, to take place within the coming 3 months.

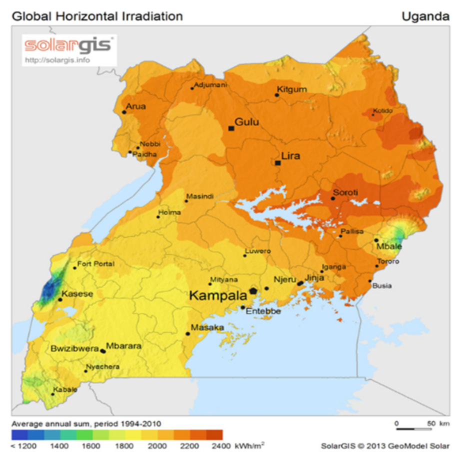
3 – DESCRIPTION OF AREAS VISITED.

Settlements located in 5 different areas were visited (Kyriandongo, Adjumani and Arua together with recently opened settlements in Moyo and Yumbe). All of these 5 areas have received and/or are receiving new refugees in the past few months, with new settlements to be likely opened in the next few weeks. Hydrogeological reports made by UNHCR exist for settlements in Adjumani, Yumbe and Arua. All of 5 areas get a high solar radiation through the year, with average of nearly 6.0 peak sun hours per day.

Refugee Locations in West Nile (Adjumani, Moyo, Yumbe and Arua).



Average annual Solar Irradiation – 1994-2010



Refuge population figures (latest UNHCR, government statistics).

Setlements Location	Population	Comments
Kyriandongo (1 settlement, 2 separated areas)	77,545	Water provision <10lpd, more refugees to be transferred in soon
Adjumani-Pakelle (19 settlements)	161,428	Some settlements with <10lpd, ongoing water trucking
Moyo (1 settlement, Palolinya)	272,206	Extensive ongoing water trucking
Yumbe (1 settlement, Bidbidi with 5 separated areas)	111,861	Extensive ongoing water trucking
Arua (1 settlement, Rhino camp ,with various separated areas)	86,770	Some areas with <10lpd, ongoing water tricking

4 – WATER POINT AND EXISTING SYSTEM: MAIN CHARACTERISTICS.

Due to unfavorable hydrogeology, water supply schemes in the older settlements of Kyriandongo, Adjumani and Arua are a combination of a few high yielding boreholes (all already either solar stand alone or solar-diesel hybrid systems) together with a large number of handpumps. In Palolinya only 2 high yielding boreholes have been drilled as underground conditions are not favorable, unlike Bidibidi where 14 high yielding boreholes where assessed and water provision in terms of quantity is somehow easier. New arrivals on these areas have put current and new water systems under stress. Water trucking was ongoing in settlements of Adjumani, Moyo, Yumbe and Arua, with a combined fleet of some 90 trucks at an average monthly cost of 400,000 USd (UNHCR source).

Existing motorized boreholes were assessed. Non-optimal sizing of systems (undersized solar systems or delivery pipes and oversized generators in hybrid schemes) was the most common problem encountered, together with no casing boreholes up to the bottom, which can create problems of high turbidity in water with the time. Lack of after sale support and low-level monitoring and technical competence of field staff was behind the 3 solar systems out of order (Kyriandongo and Adjumani).

Bad orientation of solar arrays were found in some cases (arrays facing North or with tilt angle < 10 degrees). However, the fact that all settlements are very near to Equator and the regular cleaning of all panels make this problem to have a small effect in the overall production of solar energy.

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, a problem that was reported in Kyriandongo, Adjumani and Arua.

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

Site Details				Technical Design							Priority of Recommendation
No.	Camp	BH ID	Managing Agency	Exisitng Pump	Exisitng 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	
26	Bidibidi, 1	Basecamp	Water Missions	Grundfos SP 14-31 c/w 7.5kw motor (Solar)	Solarworld 250W x 60 (20 x 3) = 15,000	211.2	107.0	104.2	211.2	Existing Solar-Diesel Hybrid system is well designed and will cover the water needs of 10,560 refugees	–
27	Bidibidi, 1	Iyete	Water Missions	Grundfos SP 9-32 c/w 7.5kw motor (Solar)	Solarworld 250W x 60 (20 x 3) = 15,000	96.8	50.0	46.8	96.8	Existing Solar-Diesel Hybrid system is well designed and will cover the water needs of 4,840 refugees	–
28	Bidibidi, 1	Reception Center	Water Missions	Grundfos SP 14-27 c/w 7.5kw motor (Solar)	Solarworld 250W x 60 (20 x 3) = 15,000	132.0	70.0	62.0	132.0	Existing Solar-Diesel Hybrid system is well designed and will cover the water needs of 6,600 refugees	–
29	Rhino	Ofua A1	Malteser	Nastec pump. Model not known	Ifrisol 250W x 16 = 4,000	??	35.0	0.0	35.0	Existing Stand alone solar capable of serving 1,750 people, but population in the area is now higher and water supply is being complemented with water trucking. Assess possibility of making the system diesel-solar hybrid. Needs to chlorinate water.	High
30	Kyriandongo	Cluster K, Disable1	DRC	Grundfos SQ, model unknown	Power Trust 85W x 46 = 3,910W	>55	4.0	51.0	55.0	Solar pumped water negligable. Wasting up to 10k USD a year cause solar not well designed/functioning. Called technician to trouble shoot. Need to chlorinate water.	High
31	Kyriandongo	Reception Center	Water Missions	Grundfos 11SQFlex, 2 units	SolarWorld 250W x 12 = 3,000W	40.0	25-40	Up to 15 in rainy season	40.0	Generator works only during rainy season for 2-3h. Hybrid supplying 2,000 people	–
32	Kyriandongo	Cluster R	Water Missions	Grundfos 11SQFlex, 2 units	–	>78	27-39	39-45	78.0	Pumps seem undesrized, re-do pumping test and change to corresponding pump if appropriate	Low
33	Kyriandongo	Cluster OQ	Water Missions	–	80W x 78 = 6,240W	>50	18-26	24.0	50.0	Pumps seem undesrized, re-do pumping test and change to corresponding pump	Low
34	Baratuku	Hybrid	DRC	5,5kW SP9A-29	Yingli 195W x 68 = 13,260W	90.0	72-78	12.0	90.0	Existing generator is 3 times size needed. Replace it for a 15kVA one when opportunity arises	Medium
35	Ayilo II	HC, DWD48292	LWF	–	120W x 16 = 1,920W	>>30	10.0	20.0	30.0	Very high pressure on water point. Lack of fuel reported as an often issue. Chlorinate water	High, as pressure very high on this water point
36	Ayilo	block E, DWD 48493	Water Missions	–	SolarWorld 235W x 40 = 9,400W	70.0	34-58	24 (rainy season)	70.0	–	–
37	Boroli	Block D	Water Missions	SQFlex, model unknown	–	28.0	10 to 28	0 to 18	28.0	Boroli camp supply at 10lpd, consider genset working longer hours	Low
38	Nyumanzi	block E, cluster2,4	Water Missions	3 SQFlex in 2 boreholes, model unknown	–	45.0	25 to 30	20 to 25	45.0	Improve cleaning of panels, Pumps seem undesrized, re-do pumping test and change to corresponding pump	Low
39	Maaji	Hybrid	DRC	SQFlex, model unknown	Yingli 250W x 7 = 1,750W	>25	20 to 25	0 to 5	25.0	Almost always solar pumping. Maaji camp at <10lpd, consider extending hours with genset	Medium
40	Ayilo	DWD 458459	LWF	SP8A-30, 5.5kW	Yingli 195W x 21 = 4,095W	–	Out of order	–	–	Solar not working since long. Likely problem with well probe or invertor. No records available during visit. Extra cost incurred of up to 15kUSD/yr.Serving as backup for water trucking to Pagirinya and Baratuku. Need troubleshooting and chlorination added.	High
41	Ayilo	HC, DWD 44968	LWF	NP 95C/31, 3kW	–		Out of order		4.0	Solar not working since long. Extra cost incurred of up to 10kUSD/yr. No registers availble during visit. Chlorinate water.Need troubleshooting and chlorination added.	High

For more details on any of the boreholes in the table, contact solarquery@iom.int

5 – Description of Solar schemes proposed for non-mechanized high yielding boreholes

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.

Implementing organizations working in the newest and largest settlements of Palolinya and Bidibidi are in the phase of considering different motorization options for the existing 18 high yielding boreholes, with at least 8 organizations declaring their interest to consider solar pumping, and so it in that sense, the visit was considered to be very timely.

The recommendations made in the table below would be able to jointly supply 2,550m3/d or water for 170,000 people (or up to 6,050 m3/d for 403,000 people if pumping time of generators of hybrid solar-diesel schemes were to be extended during the night).

Site Details				Technical Design								Priority of Recommendation
No.	Camp	BH ID	Managing Agency	Proposed Power Pump	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	Palolinya	Health Center	LWF	4kW	7,000 Wp	44.0	94.0	0.0	94.0	Stand alone solar is sufficient to meet the demand and provides an excess of 50m3/day which can serve an additional 2,500 people or be left as back up and for future need.		High, to minimise water trucking
2	Palolinya	Reception Center	LWF	4kW	7,000 Wp	144.0	58.0	86.0	144.0	Install hybrid system in order to cover the demand.		High, to minimise water trucking
3	Bidibidi 2	BH4	Oxfam	4kW	38,000 Wp	360.0	213.0	147.0	360.0	Install hybrid system in order to cover the demand.		High, to minimise water trucking
4	Bidibidi 4B	Kado	NRC	4kW	8,000 Wp	not known	39.0	0.0	39.0	Stand alone solar capable of serving 1,950 people. If population figures unclear, install hybrid.		High, to minimise water trucking
5	Bidibidi 4B	Artesian	MSF	2 x 7.5kW	31,500 Wp	72.0	332.0	0.0	332.0	Stand alone solar that uses surface pumps. The borehole is high yielding and serving a low pupulation of 3,600 but can be fully utilized to meet the water needs of additonal 13,000 people. Due its high capacity and potential, the system should be fitted with a remote monitoring function.		High, to minimise water trucking
6	Bidibidi 5	BH5	Oxfam	7.5kW	13,500 Wp	not known	81.0	0.0	81.0	Stand alone solar capable of serving 4,050 people. If population figures unclear, install hybrid.		High, to minimise water trucking
7	Rhino	Olujobo	UNICEF/ Malteser	5.5kW	11,000 Wp	not known	74.0	0.0	74.0	Stand alone solar capable of serving 3,750 people. If population figures unclear, install hybrid.		High, to minimise water trucking
8	Rhino	Wanyange C	UNICEF	5.5kW	9,500 Wp	not known	57.0	0.0	57.0	Stand alone solar capable of serving 2,850 people. If population figures unclear, install hybrid.		High, to minimise water trucking
9	Pagirinya	DWD 45471	LWF or DRC	11kW	18,600 Wp	not known	120.0	0.0	120.0	Stand alone solar capable of serving 6,000 people. If population figures unclear, install hybrid.		High, to minimise water trucking
10	Ayilo II	Not equipped	LWF	7,5kW	15,810 Wp	not known	74.0	0.0	74.0	Stand alone solar capable of serving 3,700 people. If population figures unclear, install hybrid.		High as Ayilo II <10lpd
11	Maaji II	Block 5, DWD51995	DRC	4kW	6,510 Wp	not known	55.0	0.0	55.0	Stand alone solar capable of serving 2,750 people. If population figures unclear, install hybrid.		High, as Maaji II < 10lpd
12	Maaji III	Artisian	DRC	7,5kW	15,810 Wp	not known	95.0	0.0	95.0	Stand alone solar capable of serving 4,750 people. If population figures unclear, install hybrid.		High, as Maaji III < 10lpd
13	Maaji III	N3, E31, elev.823m	DRC	7,5kW	15,810 Wp	not known	60.0	0.0	60.0	Stand alone solar capable of serving 3,000 people. If population figures unclear, install hybrid.		High, as Maaji III < 10lpd
14	Maaji III	DWD 59745	DRC	30kW	64,790 Wp	not known	98.0	0.0	98.0	Stand alone solar capable of serving 5,000 people. If population figures unclear, install hybrid.		High, as Maaji III < 10lpd
15	Bidibi, 3A	Koro -GPS 51	UNICEF/ Malteser	5.5kW	11,000 Wp	not known	59	0.0	59	Stand alone solar capable of serving 2,950 people. If population figures unclear, install hybrid.		Only high yielding bh in 3A, population of around 5000
16	Bidibi, 3B	Missing	Oxfam	_	_	not known	_	0.0	_	_		High, to minimise water trucking. These 3 boreholes might get interconnected in one loop water netwrok to supply the entire zone 3B. It is recommended that the highest yielding one is made hybrid in order to be able to respond to unknown or future needs.
17	Bidibi, 3B	Kululu-GPS 42	Oxfam	_	_	not known	_	0.0	_	_		
18	Bidibi, 3B	Yoyo	Oxfam	30kW	65,000 Wp	not known	177	0.0	177	Stand alone solar capable of serving 8,850 people. If population figures unclear, install hybrid.		
19	Bidibi, 3C	Alunga 96, GPS 50	NRC	7.5kW	15,750 Wp	not known	68	0.0	68	Stand alone solar capable of serving 3,400 people. If population figures unclear, install hybrid.		High to minimise water trucking. For zone 3C there is 1 more bh drilled by UNICEF at 12m3/h. Total population at 3C is 8,000 people. Probably wont be enough an so it is recommended to go hybrid in the one with largest yield
20	Bidibi, 3D	Alunga 98, GPS 52	NRC	15kW	30,000 Wp	80000	181	0.0	181	Stand alone solar capable of serving 9,050 people. If population figures unclear, install hybrid.		High to minimise water trucking. It would serve an area with about 4k people. Currently pumping at 16m3/h. System proposed could accomadate 5,000 people more in the area.
21	Bidibi, 3E	Yoyo Three-GPS 52	NRC	7.5kW	15,000 Wp	160000	65	0.0	65	Stand alone solar capable of serving 3,250 people. If population figures unclear, install hybrid.		High to minimise water trucking. Zone 3E count with 1 handpump and another high yielding bh being developed at the time of the visit.Estimated population at 8k people.
22	Bidibi, 4A	Abiriamajo 110 - GPS 66	NRC	4kW	7,000 Wp	80000	129	0.0	129	Stand alone solar capable of serving 6,450 people. If population figures unclear, install hybrid.		High to minimise water trucking. Current pumping rate at 12m3/h. It would serve about 4k people.
23	Bidibi, 4A	Aniti 2 - GPS 61	NRC	7.5kW	15,750 Wp	not known	126	0.0	126	Stand alone solar capable of serving 6,300 people. If population figures unclear, install hybrid.		High to minimise water trucking. It would also serve 1 local community.
24	Bidibi, 4A	Migoro 115-GPS 59	NRC	4kW	7,000 Wp	not known	30	0.0	30	Stand alone solar capable of serving 1,500 people. If population figures unclear, install hybrid.		Safe yield low, look for opportunity to solarize other bh in the area.
25	Bidibi, 4A	Migoro 116-GPS 57	NRC	4kW	7,000 Wp	not known	31	0.0	31	Stand alone solar capable of serving 1,550 people. If population figures unclear, install hybrid.		Safe yield low, look for opportunity to solarize other bh in the area.

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 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 run comparing the proposed solar systems with generator stand-alone ones (see table below), showing an *average breakeven point for solar investment of only 1.1 years, and an average reduction of expenses in installation and O&M cost of -66%.* The initial capital cost of solarizing 23 boreholes is estimated at around 1.01 million USD (cost of equipment up to the water tank) and could supply .

High Yielding non-motorized sites

Site Details				Water Output			Economic/Life Cycle Analysis					
							Generator stand alone		Solar stand alone or Hybrid		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)	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
1	Palolinya	Health Center	LWF	94.0	0.0	94.0	$19,512	$88,659	$19,366	$30,714	-65%	0.0 years
2	Palolinya	Reception Center	LWF	58.0	86.0	144.0	$19,392	$223,118	$32,253	$159,235	-29%	1.4 years
3	Bidibidi Zone 2	BH4	Oxfam	213.0	147.0	360.0	$43,827	$525,613	$100,522	$301,550	-43%	1.9 years
4	Bidibidi Zone 4B	Kado	NRC	39.0	0.0	39.0	$20,881	$90,900	$22,204	$33,552	-63%	0.3 years
5	Bidibidi Zone 4B	Artesian	MSF	332.0	0.0	332.0	$32,064	$285,719	$72,278	$90,584	-68%	1.7 years
6	Bidibidi Zone 5	BH5	Oxfam	81.0	0.0	81.0	$27,314	$151,449	$34,132	$45,588	-70%	0.6 years
7	Rhino	Olujobo	UNICEF/ Malteser	74.0	0.0	74.0	$24,342	$137,239	$29,997	$42,374	-69%	0.6 years
8	Rhino	Wanyange C	UNICEF	57.0	0.0	57.0	$23,936	$132,760	$27,480	$39,857	-70%	0.3 years
9	Pagirinya	DWD 45471	LWF or DRC	120.0	0.0	120.0	$24,391	$184,688	$42,500	$59,594	-68%	1.3 years
10	Ayilo II	Not equipped	LWF	74.0	0.0	74.0	$19,605	$170,111	$34,670	$50,123	-71%	1.1 years
11	Maaji II	Block 5, DWD51995	DRC	55.0	0.0	55.0	$14,456	$105,980	$19,507	$33,325	-69%	1,5 years
12	Maaji III	Artisian	DRC	95.0	0.0	95.0	$19,606	$185,130	$36,475	$51,932	-72%	1.1 years
13	Maaji III	N3, E31, elev.823m	DRC	60.0	0.0	60.0	$19,606	$170,112	$36,475	$42,269	-75%	1,1 years
14	Maaji III	DWD 59745	DRC	98.0	0.0	98.0	$36,611	$529,700	$120,290	$139,436	-74%	1.6 years
15	Bidibi, 3A	Koro -GPS 51	UNICEF/ Malteser	59	0.0	59	$17,917	$101,714	$27,800	$42,847	-58%	1.6 years
16	Bidibi, 3B	Missing	Oxfam	_	0.0	_	_	_	_	_	_	_
17	Bidibi, 3B	Kululu-GPS 42	Oxfam	_	0.0	_	_	_	_	_	_	_
18	Bidibi, 3B	Yoyo	Oxfam	177	0.0	177	$36,611	$534,433	$122,500	$141,646	-73%	1.7 years
19	Bidibi, 3C	Alunga 96, GPS 50	NRC	68	0.0	68	$24,361	$206,373	$45,725	$62,835	-70%	1.2 years
20	Bidibi, 3D	Alunga 98, GPS 52	NRC	181	0.0	181	$28,811	$386,813	$60,180	$77,688	-80%	0.9 years
21	Bidibi, 3E	Yoyo Three-GPS 52	NRC	65	0.0	65	$19,606	$133,256	$33,550	$49,006	-63%	1.4 years
22	Bidibi, 4A	Abiriamajo 110 - GPS 66	NRC	129	0.0	129	$16,007	$92,186	$19,200	$33,018	-64%	0.5 years
23	Bidibi, 4A	Aniti 2 - GPS 61	NRC	126	0.0	126	$19,606	$135,000	$34,590	$50,046	-63%	1.5 years
24	Bidibi, 4A	Migoro 115-GPS 59	NRC	30	0.0	30	$16,016	$117,898	$19,280	$33,098	-72%	0.6 years
25	Bidibi, 4A	Migoro 116-GPS 57	NRC	31	0.0	31	$16,016	$120,966	$19,280	$33,098	-73%	0.6 years

A similar economic analysis was run for these existing solar systems (see table below), showing an *average breakeven point* for the solar investment vs stand alone generator *of 2.6 years*, which is short –and so, very favorable to Solar schemes- when compared to other countries in the Region. *The average reduction of expenses in installation, O&M costs was estimated at -40%*. The capital and running costs of 8 hybrid systems in Kyriandongo, Adjumani and Arua have already being recovered. Another 5 hybrid systems are between 2 and 4.5 years to break even, while the remaining 3 were out of order and so, data were not available to make any economic estimation.

Existing solarized sites

Site Details				Water Output			Economic/Life Cycle Analysis					
							Generator stand alone		Solar stand alone or Hybrid		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)	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
26	Bidibidi Zone 1	Basecamp	Water Missions	107.0	104.2	211.2	$25,690	$266,644	$48,869	$174,760	-34%	1.9 years
27	Bidibidi Zone 1	Iyete	Water Missions	50.0	46.8	96.8	$25,122	$245,159	$48,869	$161,002	-34%	2.1 years
28	Bidibidi Zone 1	Reception Center	Water Missions	70.0	62.0	132.0	$24,635	$259,871	$47,813	$164,762	-37%	1.8 years
29	Rhino	Ofua A1	Malteser	35.0	0.0	35.0	$20,233	$99,763	$17,057	$29,434	-70%	0.0 years
30	Kyriandongo	Cluster K, Disable1	DRC	4.0	51.0	55.0	_	_	_	_	_	_
31	Kyriandongo	Reception Center	Water Missions	25-40	Up to 15 in rainy season	40.0	$2,500	$76,808	$11,060	$29,774	-61%	1.4 years
32	Kyriandongo	Cluster R	Water Missions	27-39	39-45	78.0	$14,100	$152,760	$26,445	$116,612	-24%	2.9 years
33	Kyriandongo	Cluster OQ	Water Missions	18-26	24.0	50.0	$15,315	$125,159	$28,915	$91,915	-27%	1.9 years
34	Baratuku	Hybrid	DRC	72-78	12.0	90.0	$19,660	$218,052	$45,760	$85,149	-61%	1.6 years
35	Ayilo II	HC, DWD48292	LWF	10.0	20.0	30.0	$10,800	$171,206	$16,600	$129,709	-24%	1.1 years
36	Ayilo	block E, DWD 48493	Water Missions	34-58	24 (rainy season)	70.0	$10,800	$74,984	$29,550	$51,879	-31%	4.9 years
37	Boroli	Block D	Water Missions	10 to 28	0 to 18	28.0	$6,500	$86,121	$22,450	$45,173	-48%	2.8 years
38	Nyumanzi	block E, cluster2,4	Water Missions	25 to 30	20 to 25	45.0	$9,800	$62,822	$26,500	$55,536	-12%	9.9 years
39	Maaji	Hybrid	DRC	20 to 25	0 to 5	25.0	$2,000	$53,412	$9,600	$25,122	-53%	1.8 years
40	Ayilo	DWD 458459	LWF	Out of order	_	_	_	_	_	_	_	_
41	Ayilo	HC, DWD 44968	LWF	Out of order	_	-	_	_	_	_	_	_

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

7 - FINAL TECHNICAL OBSERVATIONS.

Low solar technical competence is the main obstacle towards a successful solarization of existing boreholes and organizations including UNHCR and UNICEF should 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, even though the demand might be low at that time.

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 – SUMMARY OF NEXT AGREED STEPS.

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

- Public debriefing to be organized during the upcoming ECHO visit to Uganda in April.

-Internal discussion at organizational level for inclusion of Solar Pumping into country documents, country plans, strategic papers.

-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.