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FOR ALL IN A FAST CHANGING WORLD**

**Turning to sun: a case study on pilot high capacity solar
powered boreholes in emergency context in Horn of Africa**

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This case study focusses on high capacity solar powered water supply systems installed by Norwegian Refugee Council (NRC) in emergency contexts in South Central Somalia and Dadaab Refugee Camps in Kenya. The solar systems are a series of projects aiming at replacing existing diesel-powered systems in order to reduce operation and maintenance costs in deep boreholes ranging from 80m to 150m deep and with dynamic heads of as high as 170m. The systems have already reduced financial operating costs, energy dependency on fossil fuel, reduction of carbon footprint while at the same time conserving environment. Some of the projects are collaboration of Public-Private Partnership with the private borehole owners who in return have passed the benefits to the end users with reduced tariffs up to 50%. Initial cost analyses indicate a favourable return on investment of 3 to 5 years depending on the size of the solar system installed.

Introduction

Somalia is recovering from 2 decades of conflict which led to displacement of many people. The situation coupled with many slow-onset and rapid onset emergencies has weakened the traditional coping mechanisms of the communities. Majority of the refugees found refuge in the neighboring countries including Kenya, Ethiopia, Yemen and Djibouti. Those who remained in the country live in internally displaced People (IDP) camps with very minimal basic services which various humanitarian agencies are struggling to meet with limited funding. Daadab Refugee complex is located in Garissa County, North Eastern Province of Kenya, around 500 Km from Nairobi (Kenya's capital) and 80 Km from the border with Somalia. The camp host over 359,471 refugees (UN Refugee Agency (UNHCR), 2014) predominantly Somalis in 5 camps, Hagadera camp being one of them where one of this project was implemented. The camps are managed by UNHCR and activities undertaken by implementing partners including Norwegian Refugee Council (NRC) which undertakes WASH, Shelter, Food Security and Livelihoods and Education programmes spread across all the camps. Other services are provided by other humanitarian organizations.

Norwegian Refugee Council (NRC) provides WASH services in Hagadera and Kambios Refugee camps. Hagadera camp has been in existence since 1990 and has a current population of approximately 107,305 refugees (UN Refugee Agency (UNHCR), 2014) while Kambios Refugee camp was commissioned in 2012 and has a current population of 19,570 refugees (UN Refugee Agency (UNHCR), 2014). NRC operates 7 boreholes in Hagadera camp producing 3,300m³/day of treated water while Kambios refugee camp has 2 boreholes producing 605 m³/day. All the boreholes in the 2 camps are high capacity wells with tested yield ranging from 55-65m³/hr. Initially all the boreholes were using diesel power generating sets with UNHCR providing 950litres of diesel per day for water production. The boreholes are equipped with submersible pumps ranging from 30-37KW operated by 100KVA genset running for 8-15 hours per day. Since the area topography is generally flat, water from the boreholes is pumped into strategically located elevated reservoirs with capacity ranging from 100-250m³ and later distributed to beneficiaries through communal water points. Similarly in South Central Somalia, NRC provides same services to IDP camps utilizing water from private owned boreholes which are run by diesel-powered systems as well. The private borehole owners experience high operation and maintenance costs due to escalating fuel costs and not well

established supply chains of spare parts making them expensive. Humanitarian organizations have struggled to meet the water fees and other costs so as to provide water to the IDPs and donors reluctant to continue funding this kind of projects led to Private-Public partnership (PPP) between NRC and the private borehole owners, whereby roles were shared and NRC replaced the diesel powered systems with Solar PV modules and the borehole owner reduces the cost of water to the beneficiaries by more than 50% thus making the water affordable to the IDPs. In a bid to cut on operating costs whilst ensuring environmental sustainability, NRC piloted solar powered water pumping system in one of the boreholes in Hagadera and 4 more in South Central Somalia which forms our case study.

Solar system solution

The solar system in Hagadera has been designed to produce 180m³ of water per day which is 50% of the daily demand, with the rest of the demand supplemented by a nearby borehole fitted with diesel powered genset. Preliminary data collected shows the system is producing an average of 150m³ daily. The other pumps in South Central Somalia have been designed with similar concept but they are currently meeting the present demand in their respective locations. The solar systems are pumping directly to elevated water storage tanks and the water distributed via gravity to various water points and are operating on average of 8hrs daily. The installation details are presented in Table 1 below.

Table 1. Boreholes Installation details								
Borehole	Location	Depth (M)	Design Capacity/day (M ³)	Pump Type (Lorentz)	Pump Level (M)	Power (W)	Panels (No.)	Panel Rating (W)
Hagadera	Dadaab, Kenya	150	180	PS25k2 C-SJ30-22	138	30,090	102	295
Zona-K,	Mogadishu, Somalia	120	83	PS9k C-J8 44	85	9,690	102	95
Shabelle,	Mogadishu, Somalia	162	120	PS21k C-SJ30-16	105	17,760	96	185
Shaati-Gadud	Baidoa, Somalia	80	93	PS15k C-SJ17-18	75	12,580	68	185
Bonkaay I	Baidoa, Somalia	120	176	PS21k C-SJ30-16	80	17,760	96	185

All the solar systems are equipped with a pump Controller, sun-switch sensor and solar well probe sensor. The solar panels have been permanently welded on the 3.5m high steel structure to mitigate against theft with the premises guarded 24 hours. The solar well probe sensor is used to ensure water levels are within acceptable limits to prevent dry pump running which would otherwise damage the pump. The newest feature of the solar systems is capability to undertake a remote monitoring of the pumps through a pump status communicator which connects wirelessly via Bluetooth to the pump status Communicator, which relays the pump information to an online computer server. The communicator enables remote pump monitoring on an online platform removing the need for physical presence at the facility. It also alerts the operators of any impending system failure thus reducing downtime to bare minimum. A stand-by diesel generator has been provided to ensure uninterrupted water supply in case of solar system failure. Minimal operation and maintenance task required is periodic cleaning of the solar panels surface to increase efficiency for optimum water production.



Photograph 1. Submersible pump controller, power unit and communicator

Source: NRC



Photograph 2. Solar panels array

Source: NRC



Photograph 3. Installation of the solar submersible pump in Mogadishu, Somalia

Source: Solargen



Photograph 4. IDPs accessing water from Shabelle Solar Water System

Source: Solargen

Operating costs analysis

Water production using the solar system has been analysed in comparison to using a diesel generator producing an equivalent amount of water in Hagadera. Table 1 summarizes the cost analysis over a 20-year period.

Table 2. Cost analysis (US\$) in Hagadera solar water system		
	Diesel generator (U\$D)	Solar system (U\$D)
Annual fuel cost	20,052	-
Staffing cost	2,930	2,930
Annual power source operation and maintenance cost	116	-
Annual capital costs	1,162	5,000
Total annual costs	24,260	7,930
20 year cost	485,200	158,600
Water cost per m ³ (20 year)	0.37	0.12
Daily savings		45

From the analysis, \$45 is saved daily for producing 180m³ of water. This translates to \$301,125 annual savings if all of Hagadera water supply was produced using solar energy. Considering the declining financial donor support due to varied reasons that is being experienced in Daadab refugee camp, the substantial savings will go a long way in reducing donors' financial needs or be used to feel other humanitarian gaps.

Table 3. Cost analysis (US\$) in Zona K (Mogadishu) solar water system		
	Diesel generator (U\$D)	Solar system (U\$D)
Annual capital costs	1,325	2,072.25
Staffing cost	1,200	1,200
Annual diesel costs	18,396	-
Servicing	6,000	-
Total annual costs	26,921.00	3,272.25
20 year cost	538,420.00	65,445.00¹
Water cost per m ³ (20 year)	0.90	0.11
Daily savings		66

In Mogadishu, with a daily saving of 66 U\$D, the return on investment is less than 2 years without considering the re-sale of the generators and other accessories which comes as a great relief to many private borehole owners who have struggled with operation and maintenance costs and the same benefits will make the water affordable to many vulnerable households. This was also confirmed through another case-study undertaken in Dadaab in 2013. A recently installed solar system has an estimated break-even point less than

¹ Assumes no significant increase in fuel costs

three years based on operational cost savings alone and ignoring reuse or sale of the existing generator. (Lorentz, Bernt GmbH & Co. KG, 2013). This will enable clean access to safe water and reduce the occurrences of water borne diseases. The solar-powered system has provided a solution to many of the challenges witnessed from usage of diesel-powered version such as water rationing, high cost of pumping, high water bills and frequent breakdowns of the mechanized borehole pumping systems. (Muema, 2013).

System benefits

The following benefits have been realized from the pilot solar powered water systems which are still under observation to assess their long –term use.

- Annual financial savings of 45USD per day in Hagadera and 66USD per day in South Central Somalia which makes the return on investment to less than 5 years.
- Reduction of cost of water to IDPs in Somalia by 75% (from 0.11USD per 20-litre jerrican to 0.03USD)
- Reduction of operation and maintenance costs by more than 90%
- Use of solar energy does not produce harmful gases which alter ecological balance hence contributing to attainment of millennium development goal of ensuring environmental sustainability by 2015.
- The solar system is noise free while in operation thus maintaining a habitable environment free from noise pollution.
- The system can still be used to enhance food security by being replicated in farming where irrigation is the chief water source for food production. Since the system uses solar radiation, it can easily be adapted for arid areas with plenty of sunshine and scant rainfall.

The systems have remote online monitoring systems which can enable troubleshooting even in times of limited access to the sites due to insecurity.

Challenges

During the pilot solar system design, implementation and operation, a number of challenges have been encountered which have resulted in varied implications.

- The installed submersible pump (18KW) in Hagadera had the highest capacity at the time of implementation and still could not meet the high production capacity that the borehole can meet. The borehole has a tested yield of 55m³/hr with excellent recharge capability. The installed submersible pump can only meet 50% of the borehole potential when it is pumping at maximum capacity. It is envisaged that improvement in solar powered submersible pump designs in future will result in pumps capable of meeting needed high capacity requirements.
- The initial capital cost are beyond many organizations financial capability hence limiting the rate at which the projects can be replicated in other contexts although this is dependent on individual boreholes water production capacity and geographical location.
- Skilled technical personnel are required to install and commission the solar system something which is always not readily available where needed. Shortage of skilled personnel means that the few available ones are likely to take advantage of the situation by charging exorbitant rates. The system may also suffer from prolonged downtime when technical breakdowns occur.
- Despite having the solar panels permanently welded on the elevation structure and having 3 night guards, thieves have once attempted to steal the solar panels in Hagadera Camp borehole 8 but were not able to remove the . Solar panels are always in demand and attractive to thieves hence anti-theft mitigation measures should always be applied.

These are initial preliminary findings for a short period of time and detailed studies are required to establish the financial viability of the systems in these contexts and comparing the yields/production against the costs involved. Other technical issues of PV solar pumping indicate while the PV modules perform to the levels specified by their manufacturer's, the pumps tend to perform at lower levels of discharge and efficiency than specified by the manufacturers. (Wijetunge & Chandrarathna, 2006), this has however not been determined at this stage.

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