Briefing note – No. 4

Solar Power: An Alternative Technology for Pumping Water

Learning and Communications in WASH in Amhara

Introduction

Approximately 40% of rural Ethiopia (WaterAid, 2010) lacks access to clean water despite rigorous efforts by the Ethiopian government and other actors to increase water supply coverage in the country. One way of extracting water is pumping ground water using different mechanisms. Use of solar for water pumping is one alternative in the rural areas of Ethiopia since most of the population has no access to the electric grid to power mechanized pumps. Moreover, solar water pumps will be preferred in the future if proper promotional measures are taken by the concerned organizations. Solar water pumps could be preferred because of their low running and maintenance costs.

Experience with the use of solar energy technologies for water pumping in Ethiopia and especially in Amhara Region is limited. The promotion of the technology by Hope 2020 and the project of African Water Facility with Government of Ethiopia are two example of recent works in the country (AWF, 2008). Therefore, documenting any previous practices of using solar as energy source for water supply and learning from them will help to understand the advantages and limitations and then to promote and initiate development of a long term investment in these technologies.

The School of Civil and Water Resources Engineering at the Institute of Technology (ioT) of Bahir Dar University (BDU) has conducted research on community participation, technology, implementation, operation and maintenance, monitoring and evaluation, sustainability and impact of WASH project in Amhara Region. Here, the story of Abate Barage locality in Fogera Woreda of Kuhar Michael *Kebele* of south Gondar and Yebabe Eyesus locality in Bahir Dar Zuria area are presented as a case to review the technology of solar power for water supply systems.

This briefing note, extracted from the main research, provides an overview of the research specific to the technology of solar power pumping with key findings and recommendations that could be an alternative technological option in the rural water supply system. The main research document will soon be available at www.wateraidethiopia.org,or http://www.bdu.edu.et

Functional (with major disrepair) solar powered shallow well water supply system at Yebabe Eyesus, Bahir dar Zuria (Photo by: Teshale T. 2011)

Background

Since most rural areas are far from the electric service in the Amhara Region, most hand dug wells, shallow wells and boreholes are fitted with hand pumps or diesel and petrol driven generators. Some of the drawback of hand pumps include: requiring excess labour from women, lacks of additional services and, disrepair of the system due to the frequent contact of the hand pump by human beings.

In addition diesel/petrol pumps have many drawbacks such as high running and maintenance costs, unreliable supply of fuel, and poor availability of spare parts. Therefore, it is important to look for and try other sources of renewable energy such as solar, wind, and mini-hydropower.

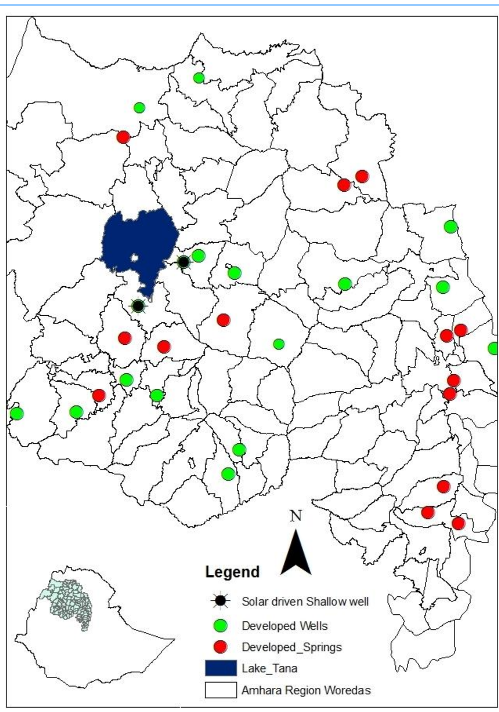
Although limited in number, solar-driven pumps installed on shallow wells proved to be a promising technological innovation and worthy of further review. Solar photovoltaic (PV) water pumping has been recognized as suitable for grid-isolated rural locations in poor countries where there are high levels of solar radiation. The recognizable challenge, however, is the high initial cost of solar water pumping systems; though it demands virtually no maintenance, and requires no fuel.

Therefore, documenting this technology practice in the region will help to gain knowledge of its advantage and limitation from past experiences as well as to consider as one technological option in the future for rural water supply implementations.

Thus WaterAid Ethiopia granted funds to the School of Civil and Water Resources Engineering at the iOT of Bahir Dar University to document practices in different issues of WASH program including rural water supply technologies. This would help to familiarize the government and non government organization involved in the rural water supply sector with the specific technology of solar panel.

Methodology

Multiple WaSH schemes were visited and evaluated using a checklist in order to document the planning and implementation of the scheme, the service it currently provides, and the challenges involved in providing a clean water supply for rural populations. Technological innovations, such as solar-driven pumps installed on shallow-dug wells, in rural water supply were highlighted in order to generate awareness in the community and the water offices and to explore options for future schemes. After explaining the objectives of the research, thirty-two schemes were initially selected based on extensive discussion with zonal and *woreda* water officials. Two of these schemes employ solar power to run pumps installed in the two shallow wells. Structured interviews were conducted with the beneficiaries of an improved water supply scheme, the district WASH committee and *Woreda* Water Resource Development office members at each of the schemes in the various *woredas*. The beneficiary interview covered topics on water use practices, participation on planning and management, and sanitation practices. The *woreda* interview covered topics on the general description of the WaSH practices, implementation approach and trainings. A total of four professionals involved covering evaluation of the two solar driven schemes. Two-day long site visits were conducted at each site by a team of two staff researchers from the School of Civil and Water Resources Engineering. A series of photographs of the various components of the WaSH scheme were taken to document particular details covered in the interviews and to confirm the current functionality of the scheme.



Location map of water points monitored in this study (Map by: Seifu A., 2011)

Key Findings

History and description of the solar powered schemes: Of the 32 schemes visited, only two were utilizing solar energy to pump the water from underground to storage tanks above ground and then to the community. Abate Barage, located in Kuhar Michael *Kebele*, Fogera *Woreda* in South Gondar, and Yebabe Eyesus in Bahir Dar Zuria have schemes that were constructed in 1994 and 1996, respectively and equipped with solar-driven pumps. The initial investment involved was excessive for rural water schemes, more than 150,000 US dollars, but included

- shallow well (~60m)
- the solar panels,
- the DC/AC inverter (converts DC to AC),
- submersible pump (~1.5 to 2 kW) with stainless steel casing,
- two imported glass-reinforced plastic (GRP) tanks of 6000 litres capacity each
- cattle trough, a shower stall, and clothes-washing basin

In both localities, the water supply scheme was implemented as a pilot to evaluate technology options in terms of the investment requirement and reliability of supply by Amhara Water Works and Construction Enterprise (AWWCE) and funded and supplied with equipment by the United Nations Children Fund (UNICEF).

Current status: Unfortunately in 2004, the pump at Abate Barage locality (~100HH) failed and the scheme became non-functional, whereas, the scheme at Yebabe Eyesus (~900HH) is still operational with major disrepair of all components. Since the pump failure was beyond their capacity at Abate Barage locality and response from regional water resources bureau (BoWRD) weren't timely for the problem, the beneficiaries requested assistance to develop a new water supply source. Following that a hand-dug well situated 100m downstream of the previous scheme were provided to the community which is constructed by the Rural Water Supply and Environmental Program (RWSEP).

According to the opinion of the ex-expert from Bureau of Water Resource Development (BoWRD), only the pump required replacement, and if this had occurred on a more timely basis, the community would continue to benefit from the water supply provided by the shallow well equipped with the solar-powered pump.

In contrast, the solar-driven pump at Yebabe Eyesus obtained continuous support from BoWRD; when the inverter failed twice it was repaired on a more timely basis. Consequently, the scheme is still operational. The serious drawback of the scheme is the lower output of energy and the consequential lower pumping rate of water during cloudy days, common in the main rainy season. And the elevating tower carrying the tanks had tilted, the pipes connecting the tanks are damaged and are leaking considerable amount of the locally scarce water. In addition, the cloth washing trough and the shower are no more in place and the cattle trough is badly damaged and do not provide services.

Points to be considered:

- From these two schemes, it was discovered that solar pumps well exceeded their design life of five years, but both sites experienced failure when the pumps and inverters malfunctioned. While the solar panels (photovoltaic cells) have proven reliable well beyond expectations, the pumps and inverters require appropriate well design and sufficient maintenance and repair for consistent and prolonged use.

- The additional cost of the imported Glass Reinforced Plastic (GPR) tanks can be avoided and local materials and equipment can be utilized to decrease the overall cost. However, the initial costs of the schemes will still be too expensive to the rural users. The capital cost of the photovoltaic cells before three years were about to be $7 to $10 per Watt peak resulting to a cost of $14,000 to 20,000 for 2kW pump (AWF, 2008). In addition an inverter for power of 2kW would cost $1000. However, in future all these prices will likely to fall down.

- Fees collected for water at solar-driven pump schemes were not sufficient enough to cover the maintenance costs of these systems. The fees were one birr per month at Abate Barage (100 HH's) and five birr per year at Yebabe Eyesus (900 HH's) for each household. To replace, for example, an inverter (the component that failed at Yebabe Eyesus), required a minimum of 1,000USD, that will take 10 years for Abate Barage and three years for Yebabe Eyesus to save money from water fees at the existing rate.

- The technology is suitable for grid-isolated remote rural locations in the country if reduction in maintenance cost can be obtained by reducing the complexity of the controller and motor pump. Andrada and Castro (2007), for example, proposed for developing countries a system that consists of a piston-type water pump, a linear motor mounted onto the piston rod that drives the pump with the help of a rope, a pulley and a counterweight instead of submersible pump and inverter.

- The technology is able to extend the service of wells beyond domestic water supply. Regular upkeep and maintenance are however necessary for all the components of a water supply scheme not just the main supply point.

Failed solar powered water supply scheme due to pump at Abate Barage locality of Fogera Woreda in S. Gonder (Photo by: Michael A. 2011)

- **Advantages from the technology are**
  - Low running costs to help offset the high initial costs
  - Less environmental impact (AWF, 2008) or pollution than other forms of energy-driven pumps (diesel, petrol, etc.) which release fumes and fuel
  - Less human contact with water supply equipment so less deterioration.
  - Able to extend the service of the well to multiple uses.
  - Utilizing a free and abundant source of energy
  - Extended operational life of water supply systems as long as the pump is well cared for and maintained.

- **Disadvantages from the technology are**
  - Excessively expensive initial cost
  - Most cost effective for low power requirement (up to 5 kW) in remote places (Omer, 2001)
  - Relatively complex technology: operation, repairs and upkeep requires well trained user committee members and frequent follow up by implementers
  - Requires elevated storage tanks to store pumped water
  - Pump powered by solar energy usually has an operation life less than that of the solar panel and also requires more aggressive maintenance and repair
  - Lower energy output thus less water observed during extended cloudy periods, which are likely to occur during the main rainy season

Recommendations

1. Solar PV an alternative but not a priority

Solar PV system can be alternative technology for remote rural areas where grid electric power isn't available. Grid electric power is the most cost effective power supply than Solar system. But this system can be alternative for diesel pump system by checking first the cost effectiveness.

2. Modifying the Solar PV system components

The disadvantages of Solar PV system are the expensive cost associated with maintenance of inverters and submersible pump. Researches should be done to adapt the system to developing countries like ours so that it will be cost effective.

3. Sustainable in off-grid remote rural areas

Despite the higher expense, the technology proved to endure for much longer time and relatively sustainable for a period of 15 years. When sufficient fund is available to support remote rural communities with larger household number, the technology can be feasible by ensuring appropriate operation and maintenance cost recovery mechanism and implementing multiple uses of the water to maximize the benefits from the technology.

4. Continuous technical support

Continuous technical support is a necessary from the regional, zonal and woreda water resources development offices as well as implementing organization for problems beyond the capacity of the users. Such technologies require long time support of appropriate experts to sustain the water supply systems.

Reference:

African Water Facility (2008). Utilisation of solar and wind energy for rural water supply in Ethiopia, appraisal report
Abdeen Mustafa Omer (2001). Solar water pumping clean water for Sudan rural areas. *Renewable Energy* 24 : 245–258
WaterAid Ethiopia (2010) Regional Water Supply and Sanitation Coverage in Ethiopia: according to 2001 EFY reports
P. Andrada, and J.Castro (2007). Solar photovoltaic water pumping system using a new linear actuator, in: INTERNATIONAL CONFERENCE ON RENEWABLE ENERGIES AND POWER QUALITY (ICREPQ'07) at Sevilla, Spain 28,29 and 30 Mach 2007. (http://www.icrepq.com/icrepq07-papers.htm)

Key Words:

Solar, technology, cost, pump, inverter

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