# MOBILE SOLAR POWER DELIVERY SYSTEM FOR RURAL APPLICATIONS

Samuel Lakeou, Ph.D. (1, 2)
Tassew Tadiwose Zewdie, Ph.D. (3,4)
(1) Professor and Chairman, Department of Electrical and Computer Engineering
University of the District of Columbia, Washington, DC, USA
(2) Director, Center of Excellence for Renewable Energy
University of the District of Columbia, Washington, DC, USA
(3) Assistant Professor, Department of Electrical and Computer Engineering, Institute of Technology, Bahir Dar University, Bahir Dar, Ethiopia, (4) Course chair, Energy and Power System

ABSTRACT: The paper describes the design and implementation of a mobile Solar Power Delivery System for use in rural areas. The work is undertaken jointly by the University of the District of Columbia in Washington, DC, USA, (UDC) and Bahir Dar University (BDU) in Ethiopia. This UDC-BDU partnership was initially supported by a Seed Grant from the US Embassy in Ethiopia. The design introduces novel features providing versatility and mobility and has beneficial applications to the rural populations whose need in potable water and water for small scale irrigation is very acute. The design is performed with the help of graduate and undergraduate students at BDU and has contributed to the infusion renewable energy in the engineering curriculum.
Keywords: stand-alone PV systems, water pumping

## 1 INTRODUCTION

This paper highlights the collaborative effort made by the Institute of Technology at Bahir Dar University (BDU), in Ethiopia and the University of the District of Columbia's (UDC) Center of Excellence for Renewable Energy and Department of Electrical and Computer Engineering, in the design and implementation of a Mobile Solar Power Delivery System for use in rural areas. This effort stems from a support received through a Seed Grant from the US Embassy in Ethiopia March 2011[1]. Initially, both BDU and UDC have implemented and evaluated stand-alone, solar-powered water pumping systems on their respective campuses [2]. In addition, several projects were undertaken jointly by UDC and Ethiopian local organizations to provide potable water to villagers in the Showa, Oromia region of Ethiopia. However, these solar powered water delivery projects were stationary and could only service a limited number of villagers [3]. The plan to design and implement a "mobile", solar energy driven power system was contemplated by UDC and BDU and then considered as a preferred option and BDU started some feasibility studies in the Amara region of central Ethiopia [3]. BDU has also started implementing a pilot station nearby the university campus, on the outskirts of the city of Bahr Dar.

## 2 BASIC CONCEPT

### 2.1 Initial approach

The model of a stand-alone, solar powered water pumping system for use in rural areas in Ethiopia was implemented on the campus at UDC, in 2006 (depicted in Fig.1 and introduced in Ethiopia [5] with the collaboration of a local, NGO, Hope2020 and the department of electrical and computer engineering of Addis Ababa University and inaugurated near the city of Ambo, in 2008. Subsequently, the department of electrical and computer engineering of the Institute of Technology of Bahir Dar University joined in and implemented also a similar model on its campus in 2011, as shown in Fig. 2.

The basic components of such a stand-alone solar-powered water delivery system include the following components:

- A panel of photovoltaic solar modules generating at least 1 KW of electrical energy;
- A controller box for controlling the reservoir water level (optional);
- A submersible pump (with a 7 USGAL/Minute at 900W or above at a head of 270 ft or 100 meters);
- A set of pipes;
- A reservoir appropriately sized for the selected services (potable water, drip irrigation, etc…); and
- A suitable water source (i.e spring, well etc…)

**Figure 1 :** Stand Alone Solar Power model at UDC

**Figure 2 :** Stand alone solar power model at BDU

The basic features of such a stand-alone system are:

- It is very simple to install, once the material is secured;
- It is relatively inexpensive ( Solar panels (4x250W) ~ $1,200, 900W DC-pump ~ $1,600, Misc (wiring/pipes) ~ $200;
- The solar pump automatically starts, soon after sunrise and continues to work unattended until sunset, unless shut off by the controller box monitoring the water level in the reservoir; and
- Simple water transfer takes place from dam to tank

Main drawbacks:

- The system is stationary and cannot service other areas; and
- There is waste of solar energy, when the system is shut off after the reservoir is filled up.

### 2.2 Improved standalone system: “double reservoir” PV pumping system

To alleviate the limitation of the standalone system described above which has a limited head (up to 100m shallow well), a double reservoir system was conceived, designed and implemented in the Jeldu area of the Oromia region.

- Effective use of DC pumps for shallow wells of limited head (~100m), thus avoiding the use of inverters; and
- A double reservoir PV, two-DC pump, pumping system as in Fig.3, for accommodating maximum efficiency of the use of the DC pumps;

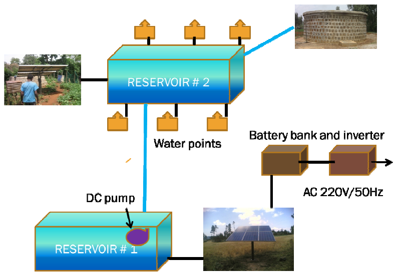


**Figure 3:** Double reservoir water delivery system (from [4]

## 3 THE MOBILE SOLAR POWER DELIVERY SYSTEM

### 3.1 Basic concept

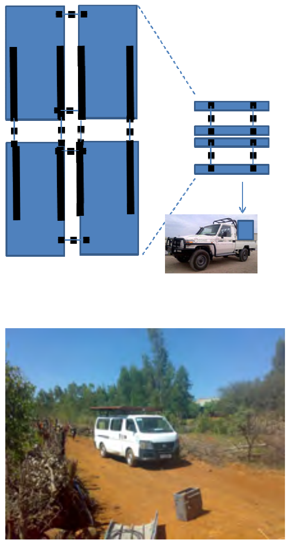

**Figure 4:** Mobile Solar Power

The “mobile” system consists of the following features:

- DC Power delivered to the pump from a “mobile” 1KW solar panel either on a predesigned truck or a van, as shown in Fig. 4;
- The pump and other accessories are also transported with the power source and connected to the source and to a pre-constructed water reservoir; and
- When the reservoir is filled, the mobile system will continue to a next site for providing a similar service.

### 3.2 Pilot system

A pilot project is now being implemented by BDU at the outskirt of the city of Bahir Dar, nearby the agricultural and water/civil engineering facilities of the campus. It is highlighted in Fig. 5. Solar modules and a submersible pump were transported from the campus of IoT to the site, with a van for initial evaluation (Fig. 4)

Its location was selected for its proximity to the campus teaching environment, where student envolvment in the project will be facilitated.

The pilot system has now a power system which realized a PV powered potable water delivery for School students and 50 household villagers at Kollela- Merawi, (BDU Village) with the capacity of 20000 $m^3$.

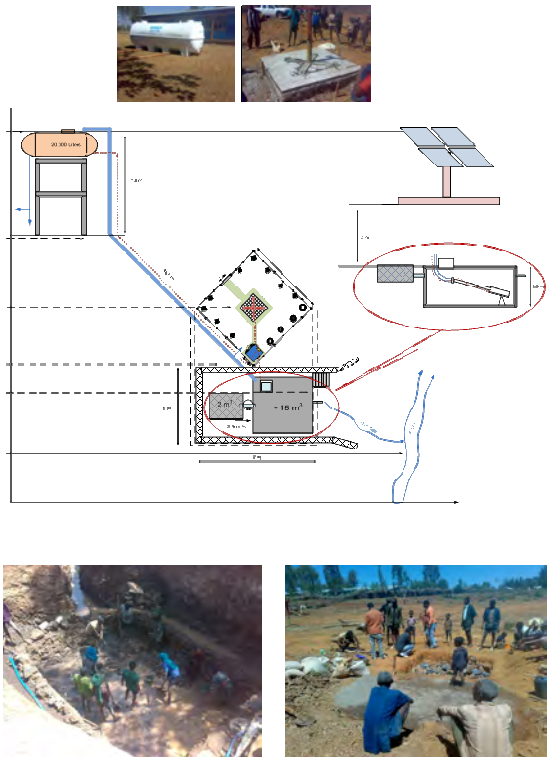

**Figure 5**: Diagram and pictures showing the design of the pilot system near the city of Bahir Dar

3.3 Site preparation

The "mobile" power system travels from site to site where water delivery is needed. However, the site must be identified based on its propensity to having a reasonably permanent or semi-permanent source of water.

The preparation of site for accommodating a "mobile" power will necessitate the following:

- Identification of a water stream, spring or shallow well;
- Building of a mini dam equipped with a low cost water discharge mechanism;
- Placement of a submersible pump operating in a horizontal position; and
- Pumping of accumulated water into a nearby reservoir.

## 4 BASIC ADVANTAGES

The "mobile" power system for water delivery presents the following main advantages:

- It is applicable to small sized river streams available in Ethiopian regions;
- It complies with the existing strategic plan and program of the BDU, which encourages the community service activity, as part of the thematic areas;
- It helps disseminate the benefit of solar powered drip irrigation for eradication of poverty;
- It fosters adaptation of traditional farming to a new culture of cultivation suitable for dry seasons;
- It enhances the capabilities of rural farmers to increase their income generation by realizing a modern type of drip irrigation; and
- It is relatively affordable to local rural communities

## 5 TARGET AREAS

As reported at the EUPVSEC27 conference, a number of areas targeted for servicing by the mobile were visited for feasibility study. They are located in the Kinbaba and Merawi Woredas as shown in Fig 6.

shown in Fig. of central located at 11° 24' 47" N and 37° 24' 7" E; 2127.8 m asl.

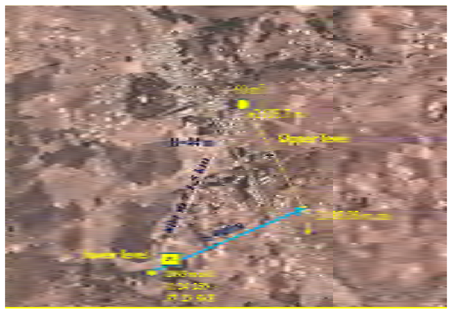

**Figure 6:** t Kinbaba and Merawi Woredas

The selected areas include:

Baydegim Spring: Constructe by Red Cross Ass. Baydegim River Spring Location: – 12 62 292..N and 36 0325605.E

Dibdib Spring
Spring Location: – 12 61 143 .N and 37 0325792 .E

Tikurit Spring: Wojji River
Spring Location – 12 61 768 .N and 37 03 27 402 E

Shileshu Spring, Birgera River
Spring Location – 12 61 217..N and 37 03 24 407 E

## 7 CONCLUSION

The implementation of a mobile power delivery system to rural communities deprived of other means of water delivery is poised to improve the living conditions of a large number of their inhabitants. The effort that is now underway at BDU is gathering support from the university administrators and the community at large. At UDC, the College of Agriculture and Urban Sustainability and Environmental Sciences (CAUSES) is currently experimenting with a similar water delivery system at its educational farm, in Beltsville, Maryland. The system will, when completed, sustain a computerized drip irrigation system. Lessons learned from this project will be infused in the current effort of BDU and UDC.

## 8 REFERENCES

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