

Anatomy of a University Sponsored Successful Hybrid Solar and Wind Based Renewable Energy Project in Rural Ethiopia

Samuel Lakeou (1,2), Ben O. Latigo (3)
(1) Department of Electrical Engineering
University of the District of Columbia
(2) Center of Excellence for Renewable Energy
(3) Dean, School of Engineering and Applied Sciences
University of the District of Columbia.

The paper chronicles the process which led to the success of a renewable energy project based on a hybrid solar and wind power system. The project is based in Farsi Senkele rural community in Ambo, Ethiopia. The initial fact-finding mission conducted by the university, including its dealings with local governmental and nongovernmental organizations as well as local universities and colleges are highlighted with emphasis on the encountered challenges. Details of the proposed technical design of the renewable power source for pumping water from a shallow well is presented. The logistical considerations, including the signing of required memorandum of understanding (MOU) with a local organization, the acquisition of private funding and material support and equipment transportation and other aspects are described. The benefits brought to the students who participated in the realization of the project are also emphasized. The project is promoted as an ideal model for the prospect of sustained university sponsored projects in developing countries.

Keyword: Stand alone PV systems, Water pumping, Hybrid, Monitoring

Introduction

The renewable energy project inaugurated on **July 24, 2008** at Farsi Senkele, near the town of Ambo in Ethiopia is the culmination of a three year collaborative work between the University of DC (UDC), a local nongovernmental organization (NGO), Hope2020 and a local university, the Addis Ababa University (AAU).

The original incentive to engage in this process stemmed from a meeting held between the president of Ethiopia and the president of the UDC in 04. The President had challenged and exhorted the university to tackle water development problems in developing countries where the shortage of potable water as well as water for irrigation is scarce. The lack of rural electrification and the challenges put forth by the millennium development goals (MDG) of the United Nations were also cited as major reasons why such focus should be directed on water development. The university took this challenge seriously and worked out a strategy to achieve the goal of providing potable water to rural communities in developing countries. At the outset, there was a consensus among the participating faculty and students that water development projects in poor rural areas would require the use of renewable energy, primarily solar and wind energies.

The strategy included the following:

1. To conduct an initial feasibility study through a fact finding mission to Ethiopia of attainable water development projects in developing countries;
2. To organize an international conference on renewable energy for developing countries in order to gather information on best practices; and
3. To prepare for an implementation phase with a pilot project site.

1. FEASIBILITY STUDY AND LESSONS LEARNED

The feasibility study consisted of a fact finding mission to Ethiopia in spring 2004 for the purpose of gathering information on the needs of the country with respect to

water development as well as on its energy resources. A delegation, including one engineering faculty, an engineering dean, an engineering student and a private businessman who is in the line of providing mobile renewable energy source was sent to Ethiopia. The delegation was provided ample assurance from the office of the President of Ethiopia that all necessary arrangements would be made by local authorities for all requested meetings with concerned agencies. During this trip, the following meetings and activities took place:

- a) Meeting with AAU officials and the faculty of the faculty of engineering;
- b) Meeting with the Ministry of Water Resources;
- c) Meeting with a recommended local NGO which is experienced in water project implementation in rural areas;
- d) Visit of a solar powered water pumping station near the city of Debret Zeit;
- e) A City Administrator of the town of Wollisso in Oromia State's, West Showa zone; and
- f) Meeting with the president of local regional business school of Ambo.

Lessons learned during the first fact finding mission.

The meeting with the University officials of AAU as well as the engineering faculty of the Faculty of Technology revealed that there is very little available in form of data base for water resources and development project. It was learnt that the department of electrical engineering has conducted some research work on solar energy and that a pilot solar/wind renewable energy setup was built. A part of the project is shown in Fig 2. Only some efficiency work was conducted on it but there was no tangible water development project sponsored by the university. The support given by the faculty and staff was however very good. We were assured that we would have all the support needed if any development work was to be undertaken.

We were then referred to the Ministry of Water Resources for seeking more information on the state of water development in the country. The Ministry's officials were most gracious in providing us with valuable information on the dire needs of the country with respect to water resources. Table.1 Summarizes the extent of water supply coverage in the country.

The Democratic Federal Republic of Ethiopia has 8 states or regions and 3 chartered cities as depicted in Fig.1



Fig. 1. Federal Democratic Republic of Ethiopia (8 Regions, 3 Chartered Cities)

▪ Total area 1,104,000 km ²
▪ Population (2004) ~70 million
▪ Urban population 20%
▪ Rural population 80%
▪ Life expectancy 42 years
▪ GNI per capita <i>US\$100</i>
▪ Demographic growth rate 2.2%
▪ Rural growth rate 1.8%
▪ Urban growth rate 4.0%



Fig. 2 Meeting with AAU Officials and (right) Pilot Demonstration Project of AAU.

Description of Type of Water Supply	Existing National Coverage	Targeted National Coverage (year 2015)
Water Supply	39.4%	69.7%
Sanitation	11.5%	56%

Table 1. Water Supply Coverage in Ethiopia (source: Ministry of Water Resources)

It was further revealed to us at our meeting at the Ministry of Water Resources, shown in Fig 3, that among the various sources, there was a growing number of water pumps operated with solar energy. The list provided to us included the following water sources:

- Dug wells
- Springs
- Motorized Boreholes
- Windmill equipped schemes
- Growing number of Photovoltaic Solar pumps



Fig. 3. UDC Delegation meeting at the Ethiopian Ministry of Water Resources

It was clear however, that the use of renewable energy was considered of paramount importance in the country due to an ever increasing energy cost, lack of spare parts, poor operation and maintenance capacity and the need to protect the environment particularly from deforestation.

The use of mobile solar power stations was also considered appropriate from the high energy cost point of view and mobility of the pastoral and semi pastoral community whose number could be estimated to be about 10 million.

The Ministry informed us that there were a few large scale programs were to be launched, including:

- A \$116 million Water Supply and Sanitation Program, with the support of The World Bank;
- A \$60 million African Development Bank program expected to employ a new stepped, performance oriented and demand responsive approach to water supply; and
- An increased participation of NGOs bilateral donors and multilateral organizations expected to alleviate water supply needs.

After two meetings with the Ministry of Water Resources we assessed that:

- No substantial hydro geological data was available for a geographic evaluation of the availability of underground water in the country; and
- No sustained effort was underway to address the water supply needs of local communities devoid of electrical power.

We then resorted to an “on the ground” evaluation of small scale water supply projects using renewable energy. The NGO, Hope2020 which was referred to us as one with good experience in rural water supply projects facilitated the following visits:

- A village potable water supply project established in 1997, near the Town of Debre Zeit with the support of an NGO, Southern Hemisphere, from Karlsruhe, Germany; and
- A local administrator of the city of Wollisso, in the Tole, Woreda of the Oromia region.



Fig. 4 Village Water Supply Project and Meeting with a local Government Official of the City of Wollisso in West Showa Zone.

The visit of the solar powered potable water supply near the city of Debre Zeit, as shown in **Fig. 4**, revealed the area’s potential for the use of solar power for pumping water. However, the installation showed very serious shortcomings including a faulty grounding scheme for the panels and a lack of adequate maintenance of the system’s inverter which was known to have repeated failures.

The visit with the city administrator of the town of Wollisso, as shown in **Fig. 4**, was most informative. The need to have in Oromia region a relief for local water supply was emphasized by the administrator. The slow access of rural electrification in these areas was cited as the main cause for the lack of water supply projects. Further investigation with other regional government officials narrowed the needs to two major areas:

- Need of pump systems for shallow wells; and
- Need to have an alternative energy source to replace the oil operated generators.

Following the visit with the city administrator, a meeting with the President of Ambo Micro Business College as shown in Fig. 8 was held in order to explore the possible business plans for sustaining a future rural renewable energy power system. Schemes which would engage the local community in setting up micro businesses to help provide funds for maintaining and securing the power system were discussed. It was retained from the meeting that there should at least be a minimal fee based water

delivery program established early on, in order to instill in the local population a sense of ownership.



Fig 5. Meeting with the President of the Ambo Micro Business College.

2. INTERNATIONAL CONFERENCE, ICREDC

The call for an International Conference on Renewable Energy for Developing Countries (ICREDC) was timed to coincide with the University's fact mission to Ethiopia. Best practices in the area of sustainable energy sources which can help alleviate poverty and serve the rural disenfranchised communities in developing countries were covered. The main topics for which a considerable number of presentations were made by international researchers include:

- Topic-1: Research in sustainable generation of renewable energy
- Topic-2: Application of sustainable renewable energy in developing countries
- Topic-3: Sustainable renewable energy models, evaluation and analysis
- Topic-4: Micro-business model, social and economic impact of renewable energy systems
- Topic-5: Renewable energy policies
- Topic-6: Curriculum development in renewable energy
- Topic-7: Biomass

At the conclusion of the conference, the University inaugurated a Center of Excellence for Renewable Energy¹ and unveiled its model design of a solar/wind based² renewable energy system capable of powering a 900-Watt submersible pump. The design was a collaborative work of all the engineering programs at the University and enjoyed the participation of several engineering students, including capstone design projects. The model design is shown in **Fig.6**.



Fig. 6 Model Solar/Wind Powered Water Pumping System on the campus of U entirely designed and mounted by U students. The center picture depicts an 800 Gal, water tank with a submersible 900W water pump.

3. MOU with a local NGO and Renewable Energy Power System Design and Implementation.

Inspired by the lessons learned from the fact finding mission to Ethiopia and the proceedings of the *ICREDC'06*, the University proceeded, through its newly established Center of Excellence for Renewable Energy, to establish a formal link with the NGO, Hope2020 in Ethiopia and to propose a model design for a shallow well application. The renewable energy power station designed at the U had shown enough reliability and was therefore adopted as a model.

A formal memorandum of understanding (MOU) was drafted³ to engage the U and the NGO, Hope2020 in collaborating for the implementation a standalone solar/wind based water pumping station in the Oromia region. A signing ceremony, preceded by a workshop on renewable energy was held in March 2007 at the Sheraton Addis in Addis Ababa, Ethiopia, as shown in **Fig. 7**. At the workshop, the U delegation highlighted the proposed design of a solar/wind based power station applicable to a shallow well situation. The design was limited to the use of a DC pump. The proposed design

was expected to fit the specifications of a shallow well as depicted in Fig. 8.



Fig.7 MOU signing between U and Hope2020 in March 07 and a Workshop held on the occasion

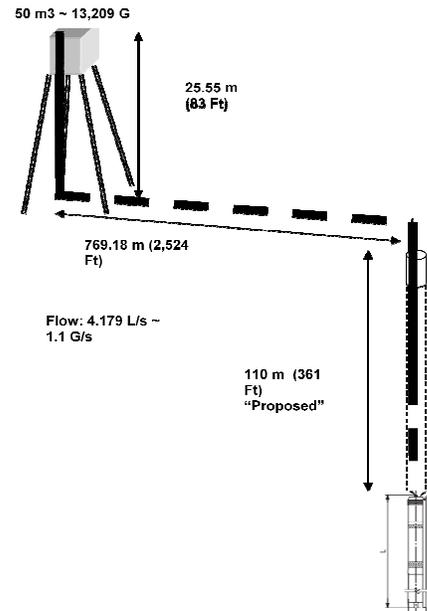


Fig. 8 Proposed well specification

The proposed pump which would satisfy the shallow well condition was selected to be a submersible, 900 Watt, DC/AC pump with a flow of 2400 Gallons/per day at a depth of 300ft. The pump was purposely selected to operate both in DC and AC, in order to provide the flexibility to avoid the use of an inverter system. The proposed renewable power system was similar to the model renewable power station designed at the U. The site selection as well as the ground work necessary for securing approval by the local authorities and community was made by the NGO, Hope2020. These preliminary arrangements included land acquisition for the location of the power system and the well to be drilled.

The university proceeded in securing funding for the project and soliciting donation of solar panels from BP Solar. It succeeded in obtaining a substantial monetary support from an anonymous donor in and a donation of ten (10), 175W solar panels from BP Solar, enough to power the submersible pump specified for the project. The university supplemented the donated equipment with a 900-Watt wind turbine and a PV mounting apparatus and shipped, as shown in Fig. 9, all equipment to Ethiopia in time for the installation.



Fig. 9. Solar panels and wind turbine equipment being shipped to Ethiopia



Fig. 10 Well drilling and erection of the pole for supporting the PV panels.

The following implementation steps were then adopted:

1. Geology/Hydrogeology/Geophysical Survey;
2. Well Drilling;
3. Erection of Pole for Supporting the Solar Panels;
4. Solar/Wind Source Assembly (Electrical Wiring);
5. Reservoir Building and Pipe Laying; and
6. Project Inauguration

The results of the hydro geological studies, including the traditional Schlumberger electrode array resistivity sounding technique, revealed the existence of a shallow aquifer at a depth commensurate with design expectations.

A local drilling company was then commissioned by the NGO, Hope2020 to proceed with the drilling and well casing. Simultaneously, the erection of the pole for supporting the photovoltaic panels was conducted by March, 2008. **Fig 10** shows clips of these activities where a faculty member and a mechanical student from the U were also on hand to assist in the work.

4. Project Inauguration

Within three months after the well drilling and the erection of the PV support pole, the NGO completed the remaining steps in the implementation plan. It completed the following:

1. Solar/Wind Source Assembly (Electrical Wiring);
2. Reservoir Building and Pipe Laying with the full participation of the local community; and
3. Project Inauguration

These steps are depicted in **Fig. 11**. The involvement of the community in the pipe laying activity was commendable. Men and women of all ages, including children were very enthusiastic in sharing their free labor in digging the trenches for the pipes.

The Hope2020 which had conducted considerable groundwork in convincing the local community was gratified by the community's overwhelming response by volunteering to participate in the hard labor of project construction.



Fig. 11. Scenes showing final stages of the construction of the renewable energy power station and water supply project. The community's participation was overwhelming.



The project inauguration was scheduled for **July 24, 2008**, one day after a workshop was conducted in the capital Addis Ababa in collaboration with the NGO, Hope2020 and the Addis Ababa University's, Department of Electrical and Computer Engineering. At the workshop, the delegation from the U outlined the various obstacles encountered in the implementation of the project and announced the success of the project. Professors from the AAU expressed their commitment to collaborate in the long term technical maintenance and monitoring of the project by assigning dedicated staff. The discussion was open to an audience which included a large number of representatives from local and international NGO's with a keen interest to promote renewable energy projects in the country. The workshop caught the attention of the government of Ethiopia at the highest level. In fact, as shown in **Fig. 12**, the President of the Federal Democratic Republic of Ethiopia was in attendance and participated actively in the discussions that took place.

The inauguration of the renewable energy project took place on July 24, 2008 at Farsi Senkele, in the presence of the President of Ethiopia, The Dean of the School of Engineering and Applied Sciences of U and the U's Director of the Center of Excellence for Renewable Energy. Also in attendance were the country's Minister of Mines and Energy as well as members of the

diplomatic corps, including the ambassadors of the USA, Germany and Austria. Scenes of the inauguration are shown in Fig. 13.

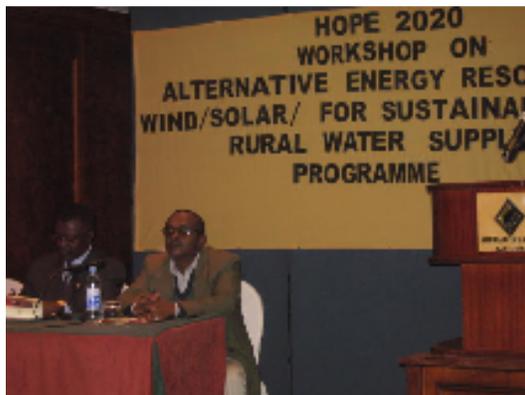


Fig. 12 Second Workshop on Renewable Energy Project. The President of Ethiopia is shown on the right picture (second right on the front row).

The turnout of the local community at the inauguration ceremonies was truly overwhelming. The community manifested its sincere appreciation of the project, which has brought to it potable water for the first time. Various members of the community, including elderly, were interviewed to express their comments on the project and invariably attested that it would bring to their families a most needed source of potable, which will enable them to combat poverty and disease. With the 10,000 liter reservoir, three hundred families are now able to get a daily ration of 50 liters of potable water, tested to be safe to drink by the Pasteur Institute, as required by law.



Fig. 13 Scenes from the Inauguration Ceremony.

V. Conclusion and future plans.

The implementation process of the joint U/NGO/AAU renewable energy project at Farsi Senkele, has been very instrumental for understanding through experience, the various obstacles and hurdles inherent to the collaboration with an NGO and local authorities of a developing country. These difficulties could be extrapolated to other countries with comparable level of development. A similar project can be envisaged for countless rural communities in a number of developing countries where rural electrification is not projected to be implemented for several years to come. It is believed that academic institutions across the world should consider teaming up with indigenous NGO's for implementing small scale but reliable projects. The modest project cost of about \$50,000 is a small price to pay when contrasted with the benefits brought to the local community in form of better health care and better standard of living. In the future, it is planned to implement similar projects at a few more sites in the Oromia region of Ethiopia. A web based data collection, including daily power delivery, water flow etc... is expected to be completed and carried out by the staff of Addis Ababa University.

Acknowledgments

Donation of photovoltaic panels from PB Solar and monetary donation from the “anonymous donor” from Northern Virginia have been instrumental in the successful completion of the project.

References:

- [1] International Conference on Renewable Energy for Developing Countries (*ICREDC'06*) (<http://icredc.udc.edu>)
- [2] Center of Excellence for Renewable Energy (<http://cere.udc.edu>)
- [3] “Design of a Low Cost Solar Tracking Photovoltaic Module and Wind Turbine Combination System”, ASEE06.
- [4] MOU signed between the U and Hope2020 (<http://cere.udc.edu>)
- [5] <http://rredc.nrel.gov/solar/calculators/PVWATTS/version1>