Increasing sustainability of rural community electricity schemes – case study of small hydropower in Tanzania

Wim Jonker Klunne[1] and Emmanuel G. Michael[2]

[1]Senior Researcher Rural Energy & Economic Development
Council for Scientific and Industrial Research (CSIR)
PO Box 395, Pretoria 0001, South Africa
Telephone: +27 12 841 3993, Fax: +27 12 841 4054, Email: wklunne@csir.co.za

[2]Senior Consultant Sustainable Energy & Climate Change
Camco Advisory Services (Tanzania) Ltd.
Telephone: +255 713 60 77 66, Email: imma_mike@engineer.com

ABSTRACT: Local small scale hydropower resources can play an important role in providing electricity to rural areas in Africa, in particular those areas remote from the national grid.
The large knowledge base on technical aspects of small hydropower indicates a proper understanding of the technology involved. However, at the same time the number of hydro projects implemented does not reflect the enormous potential that exists in Africa, suggesting other barriers than the technology itself are still persistent.
Studies on rural electrification conclude that technology issues are only part of the reason why energy access is still very low in certain areas. The way new (energy) technology is introduced in rural areas and the systems set up for operation and maintenance are equally important. Next to a conducive environment at national level with relevant regulatory, legislative and financial frameworks in place, emphasis needs to be put on the institutional design and practices incorporated.
To evaluate the role of institutional and management arrangements and practices adopted by developers on the sustainability of these systems, the research uses off-grid hydro schemes in the Southern Highlands of Tanzania as case studies. The article describes the contribution of financial, social and technical aspects to the sustainability of the isolated power schemes.
Based on the case studies conclusions are drawn towards methods that will increase the sustainability of hydro systems.
Keywords: small hydropower, mini grids, rural electrification, Africa, governance

1. INTRODUCTION

1.1. Energy access in Africa

Sustainable energy provision is regarded as a major challenge, especially in Africa where large proportions of (rural) population do lack access to (basic) energy services. On the continent over 500 million people do not have access to electricity. This translates to two thirds of the population, while in rural areas up to 92% of the population lives without electricity. Although the electrification rates do differ per country, rural areas in general lack access to adequate, affordable, and reliable energy services. It has generally been agreed that providing access to energy is an absolute necessity in order to reach the Millennium Development Goals [2, 3].

The provision of sustainable energy options is currently very high on the international agenda. Particular the provision of energy derived from renewable sources. This was already the case at the World Summit on Sustainable Development (WSSD) in Johannesburg (2002), and reinforced at recent high level conferences.

The negotiations within the United Nations Framework Convention on Climate Change (UNFCCC) did also see a remarkable shift towards the inclusion of energy policy. While in Bali (December 2007) the attention was mostly on climate change, the Poznan conference end 2008 saw delegates talking about climate change and energy policies. Although the expectations on concluding a follow-up programme on the Kyoto protocol are mixed, it is widely anticipated that the COP15 meeting in Copenhagen late 2009 will address the energy access issue prominently.

Also the international attention for increasing energy access in Africa through initiatives led by the World Bank and the donor community indicate an international recognition of the role of energy in development with a special attention to increasing access to energy for rural areas.

The traditional way of providing electricity to rural areas through the extension of the national electricity grid becomes prohibitively expensive due to geographical barriers (distance and terrain) and due to initial low demand for electricity. A viable alternative for grid extension is provided by renewable energy sources that use local resources.

Substantial numbers of projects and programmes have been implemented in Africa providing solar systems to rural populations. However, it has become clear that the costs of PV systems are very high and that they do not provide households with the level van energy services they aspire.

Small scale hydro, often implemented through local isolated mini grids, is able to offer a higher level of energy services than solar home systems.

1.2. Small scale hydro in Africa

Small scale hydropower has a long history in general, but also in Africa. For example the first system in South Africa was a 300 kW station on the slopes of Table Mountain, which was inaugurated in 1895 [4]. All over Africa church missions were particularly active in implementing small scale hydropower installations. In Tanzania, more than 16 small hydropower systems were installed by church missions in the 60’s and 70’s of last century that are still operating [5], while in Zimbabwe for example large scale commercial farmers in the Eastern Highlands of the country installed hydro stations as early as the 1930’s [6].

Many countries in Africa do have a rich history of small scale hydropower, but over time large numbers of these stations have fallen in disrepair. Some because the national grid reached their location but others because of lack of maintenance or pure neglect.

Recently initiatives have seen the light in a number of countries in Africa to revive the hydropower sector [7], either through international development agencies or through private sector led initiatives.

1.3. Making hydro sustainable

A large array of studies does exist that look into the technical aspects of the development of small scale hydropower [8-11], suggesting that at the current moment in time we do have a proper understanding of the technology involved. However, the uptake of that same technology does not see a reflection of the enormous technical potential that exists in Africa, suggesting that other barriers than the technology itself are still persistent.

Based on generic studies on rural electrification around the world understanding has been developed that technology issues are only part of the reason why energy access is still very low in certain areas and that the way new (energy) technology is introduced in rural areas as well as systems set up to operate and maintain these technologies are equally important.

2. SMALL HYDRO IN TANZANIA

2.1 Overview

Tanzania has a substantial potential for small scale hydropower development with a considerable number of schemes already in existence. Research revealed that not all existing hydro schemes are properly documented, nor is their current status. Particular small village level schemes developed by the Roman Catholic Diocese are not well known to the public [1].

Three hydro schemes implemented by the Njombe Diocese Catholic Church Mission were extensively reviewed by Michael [1] on their sustainability in order to investigate the reasons for their success. This article describes these three hydro stations and draws conclusions for sustainable implementation of small village level hydro schemes.

The next paragraphs describe the three case studies after which an analysis is given of the results. Technical details of the systems can be found in Table I.

2.2 The Matembwe village hydro scheme

The Matembwe village is located in Njombe District at 57 km from Njombe Township. The initiative to develop the scheme started in 1981 where the Italian NGO CEFA introduced the idea to the local stakeholders including the diocese, the local government and the inhabitants of the villages concerned. The actual construction started in March 1983 and the plant was commissioned in 1986 when the scheme started operating. To-date, the plant is still operating with no major problems.

The primary aim of the scheme is to power the vocational centre ran by the Matembwe mission which used to be powered by the two diesel generators. The main aim of the centre is to support and strengthen the capacity of the local people on agricultural activities and animal husbandry.

The scheme has an installed capacity of 150 kW and supplies electricity to two villages (Matembwe and Image) located 5 km apart for commercial and social centres as well as individual households. The productive loads at the vocational centre cater for approximately 42% of the total electricity consumption of the scheme.

The first years of operation two village committees were responsible for managing the project. As the capacity of these committees was found to be insufficient the management was handed over to the Matembwe Village Co. Ltd., who manages the vocational training centre. The ownership of the scheme is shared by the Diocese, CEFA, the village authority and the District Authority.

Since the commissioning of the hydro scheme the national electricity utility TANESCO has extended its electricity grid to the village, effectively meaning that villagers have the choice between either connecting to the Matembwe hydro scheme or TANESCO. Some villages have opted to use a TANESCO connection as back up to the existing hydro connection to be ensured of continued power supply in cases were the hydro system is shut down due to insufficient water availability.

Development	MATEMBWE	MAVANGA	LUGARAWA
Project location	Matembwe Village, Njombe District, Iringa Region	Mavanga Village, Ludewa District, Iringa Region	Mavanga Village, Ludewa District, Iringa Region
Implementers	CEFA, RC church-Njombe Diocese	German donors and RC church-Njombe Diocese	Swiss & German donors and RC church-Njombe Diocese
Project duration	Started in 1983 and commissioned in 1986	Stared in 1999, operational since 2002	Installed in 1979 single phase power, three phase in 1995
Area of distribution	Matembwe and Image	Mavanga and Mbugani	Lugarawa and Mdilidili
Source of water	UDEKA stream	MOLOMBOJI stream	LIFUNGULU stream
Installed capacity	150 kW	2 x 75 kW	140 kW
Application	Domestic uses in villages, commercial uses in Matembwe Village Company, social centres and light commercial loads	Domestic uses in villages, commercial applications in micro-enterprises and service institutions	Mission hospital and light load uses in villages
Technical summary			
Intake level (masl)	1489.5	N/A	N/A
Tail race (masl)	1480	N/A	N/A
Gross head (m)	10	N/A	N/A
Net head (m)	9.5	N/A	8
Daily flow (m^3/sec)	0.4 – 1.7	N/A	2.542 (rated flow)
Flood flow (m^3/sec)	10	N/A	N/A
Catchment (km^2)	24.3	N/A	N/A
Intake facility			
Intake weir	Concrete wall across the stream lying on the rock bed	Concrete wall across the stream lying on the rock bed	Concrete wall across the stream lying on the rock bed
Penstock	Steel pipe covered with concrete, 22m long	PVC pipe	Still pipe covered with concrete
Turbine type	Kaplan	Francis	Osserburg Crossflow
Transmission and Distribution			
Transmission/ Distribution line	To village 4 and 5 km To mission 2 km Total transmission 13 km	6 km	3 km
Cables	Four wire overhead cable.	Four wire overhead cable	Four wire overhead cable
Transmitted voltage	10,000 V		10,000 V
Transformer	100 kVA		100 kVA
Metering	All loads	Only commercial loads	All loads
Beneficiaries			
Households	280	570	309
Institutions	9	14	9
Commercial loads	20	46	18

Table I Overview of the three hydro stations used in the case study (based on [1])

2.3 The Mavanga village hydro scheme

Mavanga village is located in the Iringa Region, Ludewa District, Liganda Division, at a distance of 170 km from Njombe Township.

The main reason to develop the project in 1999 was high costs incurred by the diocese for running a generator to power the local health centre. The diocese, in collaboration with German donors (Duren Parish & Solligeni Parish) introduced the idea to local stakeholders including local government and the community.

The plant construction was completed in 2002, with generation started in the same year. The plant electrifies the whole Mavanga ward comprising of the villages Mavanga and Mbugani.

Mavanga electricity project's ownership is threefold, it is owned by the Diocese, ward community and the donor. The management of the scheme is under the local committee named Mavanga Electricity Project Committee (MEPC). The MEPC is made up of 10 members, the chairman and the secretary. While the donor and the church are there to advice and help when the need arises, the committee is responsible for day to day activities including bills collection, conflict resolution, if any, and solving technical problems. The committee also acts as a representative of the villagers in electricity matters. Technical sustainability is ensured through a contractual obligation of the installing engineer to provide technical back up for the first eight years of plant operation, ensuring a gradual skills transfer to the MEPC.

No future connection to the national TANESCO electricity network is foreseen due to the remote location of the scheme at 180 km from the grid.

2.4 Lugarawa village hydro scheme

The Lugarawa village hydro scheme was installed in 1979 by RC missionaries with the aim of powering the mission hospital. In 1982 the project extended its service to supply electricity to the surrounding communities in Lugarawa and Mdilidili for low load applications only.

Lugarawa electricity scheme is owned by the diocese of Njombe and managed jointly by the village committee and the mission hospital. The village committee is made up of 14 members who represent various groups of people/institutions. The institutions represented in the committee are the village authorities of the two villages, the hospital, hamlet leaders, secondary school, and the church mission. The church mission is the main administrator and the doctor in charge of the hospital is also part of administration team. Two technicians are also part of the committee.

2.5 Analysis of results

The development of the hydro schemes was strongly embedded in the local structures and the intended beneficiaries were involved in the conceptualising and construction of the plants from a very early stage. Although all three schemes were developed by the diocese, the management models used were adapted to the local situation.

The three hydro stations were developed following all required legal procedures and ownership is well documented and structured. Particular in the case of Matembwe this proved to be an essential element when the national grid reached the village and the hydro plant was able to continue operation in co-existence with the TANESCO grid.

In all three cases the presence of local technical skills to maintain the systems (or arrangements in place for the original engineer to provide these services) created an environment in which the villagers were able to solve technical problems them selves. This has clearly brought trust to the users over the service delivery and was mentioned as an important factor in willingness to pay for the services. Contributing factor in this respect is the high quality of the technical installations for the hydro station and distribution networks.

Financial sustainability of the schemes is ensured through the productive uses by the diocese operated vocational centre and health facilities. In all three cases power delivery to the villagers is regulated through bylaws, including penalties for non-payment and re-connection after payment defaulting.

3. CONCLUSIONS

General evidence on rural electrification projects does suggest that the sustainability of implemented projects is not primarily depending on technical issues. The article described the cases of three isolated mini grids in Tanzania using small scale hydropower technology to serve a total of over 1100 households, 32 institutions and 84 commercial loads with electricity.

Careful planning procedures catering for technical capacity, good institutional arrangements, managerial capacity and economic considerations, as well as multi-stakeholder involvement from the planning phase onwards, have resulted in the sustainable operation of the three hydro plants.

Although hydropower is a very site specific technology from a technical point of view, the implementation of hydro projects can be made more sustainable if attention is given to the non-technical issues right from the start. The current research has proven that a consistent approach with final sustainability of the projects in mind, can lead to properly ran mini grids powered by hydropower that are able to bring a difference to remote areas of Africa.

As in all three cases the hydropower development was initiated by the same entity it is recommended that a larger scale research project is undertaken that includes other development models, as well as a wider geographical coverage, in order to develop a management model that will assist in ensuring the sustainability of such developments.

REFERENCES

1. Michael, E.G., *Institutional Design and Practices for Sustainable Decentralised Energy Systems Development for Rural Electrification. The Case of Isolated Mini-Hydro Power Systems Developed by Catholic Church Mission, Njombe Diocese, Tanzania*. 2008, University of Twente: Enschede.
2. UNDP, *Achieving the Millennium Development Goals: the role of energy services. Case studies from Brazil, Mali and the Philippines.* 2005, United Nations Development Programme: New York.
3. DFID, *Energy for the poor, Underpinning the Millennium Development Goals*. 2002, DFID: London.
4. Barta, B., *Capacity building in energy efficiency and renewable energy. Baseline study - hydropower in South Africa*. 2002, Department of Minerals and Energy: Pretoria.
5. Mtalo, F., *Small scale hydropower for rural development*. 2005, Nile Basin Capacity Building Network NBCBN Research cluster.
6. Klunne, W., *Hydro-power end-uses at Svinurayi co-operative (Cashel Valley, Eastern Highlands, Zimbabwe)*. 1993, University of Twente: Enschede.
7. Jonker Klunne, W., *Small hydropower development in Africa*, in *ESI Africa*. 2007.
8. Khennas, S. and A. Barnett, *Best practices for sustainable development of micro hydro power in developing countries*. 2000, ESMAP: Washington.
9. Harvey, A., *Micro-hydro design manual, a guide to small-scale water power schemes*. 1993, London: Intermediate Technology Publications Ltd.
10. Fraenkel, P., et al., *Micro-hydro power, a guide for development workers*. 1991, London: Intermediate Technology Publications Ltd.
11. Inversin, A.R., *Micro-hydropower sourcebook*. 1986, Washington: NRECA.