Off-grid microhydro to serve rural areas in Africa

Wim Jonker Klunne
Senior Researcher,
Council for Scientfic and Industrial Research

Wim Jonker Klunne is a renowned microhydro expert and has worked on a wide range of education, research and implementation projects around the world on behalf of the African Development Bank, World Bank, ECN, UNDP, GEF and bilaterals.

Currently Mr. Klunne is working at the Council for Scientific and Industrial Research (CSIR) in South Africa as senior researcher Rural Energy and Economic Development. One of his research projects is looking at the sustainability of microhydro projects in Eastern and Southern Africa.

Mr. Klunne is the driving force behind the microhydropower.net internet portal and discussion forum, as well as the webmaster of hydro4africa.net.

Sustainable energy provision is regarded as a major challenge, especially in Africa where large portions of the (rural) population 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 widely been agreed that providing access to energy is an absolute necessity in order to reach the Millennium Development Goals.

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 initial low demand for electricity. A viable alternative for grid extension is provided by renewable energy sources that use local supplies.

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 photovoltaic systems are very high and that they do not provide households with the desired level of energy services.

Micro scale hydropower, often implemented through local isolated mini grids, is able to offer a higher level of energy services than solar PV. In the case of Kenya, research by Maher et al (2003) revealed that hydro stations in the pico range (in this case defined as less than 5 kW) are able to supply electricity to households at a fraction of the cost to the end-user compared with solar PV or using a car battery charged at grid connected charging stations.

Microhydro in Africa

There is enormous exploitable hydropower potential on the African continent for large and small scale hydropower, but despite this potential Africa has one of the lowest hydropower utilisation rates. While large-scale hydropower development is becoming a challenge due to environmental and socio-economic concerns, and more recently its vulnerability to changing climates and hence water availability in the main water bodies, micro hydropower development continues to be an attractive resource especially in remote parts of Africa. The fact that microhydro installations tend to use only part of the available water in rivers makes them less vulnerable to changes in water quantities due to climate change.

Microhydro is a proven technology that can adequately contribute to the electricity needs of African countries.

Micro scale hydropower has a long history in Africa. The first system in South Africa was a 300 kW station on the slopes of Table Mountain, which was inaugurated in 1895 (Barta 2002). In Zimbabwe large-scale commercial farmers in the Eastern Highlands of the country installed hydro stations as early as the 1930's (Klunne 1993), while in Tanzania, more than 16 small hydropower systems installed by church missions (which were particularly active in implementing small-scale hydropower installations) in the 1960's and 1970's are still operating (Mtalo 2005).

Many countries in Africa 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.

However, in a number of countries there has recently been a revival of the hydropower

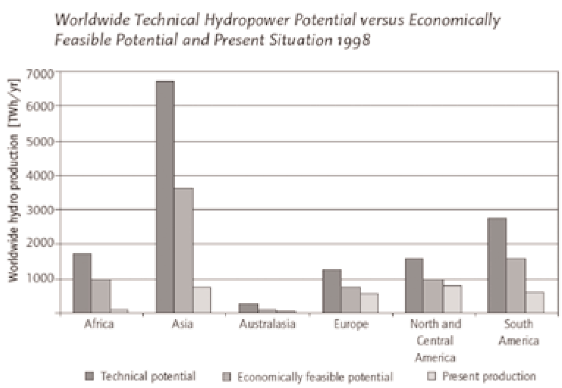

Figure 1: Hydropower potential worldwide (IEA 2003)

sector, either through international development agencies or through private sector led schemes. In particular new initiatives have been developed in Central Africa (Rwanda), East Africa (Kenya and Tanzania) and Southern Africa (Malawi, Mozambique and Zimbabwe) focusing on implementing small-scale hydropower projects.

Barriers

Micro hydropower exploitation faces numerous challenges, most of them being part of the larger picture of general barriers for the uptake of renewable energy and independent power producers. These generic barriers can be summarised into the lack of clear-cut policies on renewable energy and associated requisite budgetary allocations to create an enabling environment for mobilising resources and encouraging private sector investment, and the absence of lost-cost, long-term financing models to provide renewables to customers at affordable prices while ensuring that the industry remains sustainable.
Specifically for microhydro, large-scale implementation is hindered by:

- Lack of access to appropriate technologies in the mini, micro and pico hydro categories, which because of small heads and high volumes or very high heads and low volumes poses special technical challenges.
- Lack of infrastructure for manufacturing, installation and operation. Most of countries in Africa do not have the facilities to manufacture even the most rudimentary turbines or parts, which might be critical in maintenance of the schemes. An example is the availability of capacity to manufacture high-density polyvinyl pipes that can serve as good penstocks for the micro hydro schemes. Few countries have these products and as such, exploitation of otherwise simple sites has been hampered by this deficiency.
- Lack of local capacity to design and develop small hydropower schemes for areas sometimes considered too remote.

Generally, most of the countries lack specialisation to undertake feasibility studies, these being detailed studies that would include comprehensive design and costing of the schemes so as to make a meaningful impact on utilisation of small hydro sites.

Current experience
Case study: The Tungu-Kabiri community hydro project in Kenya

The Tungu-Kabiri community micro hydropower project in the rural area around Mount Kenya demonstrates how the use of micro hydropower can bring development to rural areas in Africa. However, it also demonstrates how national policies can hamper the uptake of the technology.

About 96% of the rural population in Kenya still lack access to grid-based electricity. A pilot project initiated by Practical Action Kenya has shown the potential for decentralised micro hydro schemes to provide access to electricity.

In 1998, Practical Action, in collaboration with the Kenyan Ministry of Energy and with funding from the GEF Small Grants Programme at the UNDP, undertook a pilot project to illustrate the potential for decentralised microhydro schemes for rural, off grid electrification, with the Tungu-Kabiti community 185 km north of Nairobi as a pilot project Ebrahimian (2003).

About 200 members of this 300-household community came together and formed a commercial enterprise to own, operate and maintain a micro hydropower plant. Each individual bought a share in the company, with a maximum share value of about US$50. The members also contributed labour, dedicating every Tuesday for over a year to the construction work, which was overseen by the Ministry of Energy and Practical Action. Involving the community in all aspects of project development from the start was critical to reduce local technical barriers and it ensured that the community could effectively maintain and repair the micro hydropower system themselves.

The microhydro system is fed off the local river from which water is diverted by a small weir. Via a canal and a penstock the water is delivered to an 18 kW turbine. The cost of the system was US$ 3495/kW installed.

The micro hydropower plant is owned and managed by the community, and this complete community ownership has been central to the project's success. A 10-member community power committee manages the day-to-day operations of the plant, and this committee also conducts consultations with the wider community about how the power generated from the system should be used. The electricity is currently used for micro enterprises, such as a welding unit, a battery-charging station and a beauty salon.

When the hydro system was installed, it was envisaged that the houses of the members would also be electrified through a local

Figure 2: Tungu-Kabiri project – opening spillway

mini grid. In preparation the locations of all houses were mapped using a GPS receiver and the most economic way of laying out the mini grid was determined. Unfortunately, although technically perfectly feasible, the mini grid was never installed as the national Kenyan electricity distribution laws prohibit anyone else other than the national distribution company to distribute and sell electricity.

This project has shown that micro hydropower can effectively meet the energy needs of poor off-grid communities. It has demonstrated that communities are willing to invest time and money for improved energy services, and can organise themselves to build and operate a micro hydropower plant. However, it also demonstrated that the local legal framework might not be conducive to developments like this.

Conclusions

Microhydro has the technical capability of providing electricity to rural areas of Africa currently without it. Presently there are several iniatives underway that are aiming to install a large number of microhydro schemes to serve rural areas. Although some information is available on the technical aspects of these projects, little has been published on the implementation models used in these projects.

From the analysis of a number of the current initiatives it is very clear that microhydro developments need to be embedded in a national program for capacity building and industrial development in order to foster the emergence of a new industry. Particular attention needs to be given to governance issues related to hydro stations as experience from the described projects suggests that linkages with ongoing economic activities will ensure proper management of the system.

Evidently the inclusion of entrepreneurs/ private sector developers could benefit the sustainability of the systems, although this does, in most instances, also come with requirements from the financiers of these private developers which have shown, in the case of Rwanda, a tendency to favour developments that feed into the national grid as this ensures a steady income stream for the enterprise.

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