Small hydropower for rural electrification in South Africa - using experiences from other African countries

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Abstract

Local hydropower sources can play an important role in the electrification of rural areas in South Africa remote from the national electricity grid. To ensure the sustainability of hydropower developments it is essential that lessons learned in other African countries are taken onboard.

As the potential for small hydropower (schemes with an installed capacity of less than 10 MW) is typically found away from the larger population areas it is a very suitable energy source for rural electrification purposes. It can be used either as standalone power source or in hybrid systems with other energy sources. Mini grids powered by hydropower can be designed in such a way that they will be able to feed into the grid once that has reached its location.

This paper reviews the current situation with respect to small hydropower development for rural electrification in other African countries. It specifically looks at the implementation models used and the associated governance issues, in light of the sustainable operation of the plants.

The paper will draw conclusions on the merits of different implementation models in relation to the sustainable development of small hydropower and identifies lessons learned for the implementation of small hydropower in South Africa.

1. INTRODUCTION

There is enormous exploitable hydropower potential on the African continent, but despite this massive potential for large and small scale hydropower, 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, small hydropower development continues to be an attractive resource especially in remote parts of Africa. It is a proven technology that can be connected to the main grid, isolated grids or as a stand-alone option, or combined with irrigation systems. Small hydro can adequately contribute to the electricity needs of African countries.

Although there is no internationally agreed definition of “small” hydro, the upper limit is usually taken in line with the World Commission on Dams as 10 MW of installed capacity, although large countries as China and India tend to put the limit higher at 50 MW and 25 MW respectively. Within the range of small hydro, distinction can be made between mini hydro (below 1 MW), micro hydro (below 100 kW) and pico hydro (below 20 kW), each with its own specific technical characteristics. Micro and pico hydro installations are typically used in developing countries for energy provision to isolated communities where the national electricity grid is not available, whereas mini hydro tends to be grid connected. Micro and pico hydro can also differ from mini hydro due to the extended possibility of using local materials and labour in the case of first two, while mini hydro typically involves more traditional engineering approaches and will usually need a heavy access road for delivery of materials and electro-mechanical equipment.

In this article all hydro installations with a size below 10 MW are referred to as small hydro.

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 (Barta 2002). 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 (Mtalo 2005), 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 (Klunne 1993).

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 (Jonker Klunne 2007), either through international development agencies or through private sector led initiatives. Particular in Central Africa (Rwanda), East Africa (Kenya and Tanzania) as well as Southern Africa (Malawi, Mozambique and Zimbabwe) new initiatives are focusing on implementing small scale hydropower projects.

Situation in South Africa

Although not very well documented, small scale hydropower used to play an important role in the provision of energy to urban and rural areas of South Africa. The first provision of electricity to cities like Cape Town and Pretoria was based on small scale hydro, while also smaller towns started local distribution of electricity through isolated grids powered by small hydro stations. However, with the expansion of the national electricity grid and the cheap, coal generated power supplied through this grid, large numbers of systems were decommissioned. A typical example in case is the Sabie Gorge hydro station with three 450 kW turbines, commissioned in 1928 to serve the town of Sabie in Mpumalanga, which was closed in 1964 after the area was connected to the national ESKOM grid (ESKOM 2003).

The South African Renewable Energy Database (Muller 1999), as developed by the CSIR, did investigate the available renewable energy resources in the country, including the potential for hydropower. Which was detailed for the Eastern Cape region through a three-year investigative project entitled "Renewable energy sources for rural electrification in South Africa". The primary objective of this project was to identify the commercially viable opportunities for rural electrification in the Eastern Cape Province of South Africa using wind, hydro and biomass powered energy systems. The maps in figures 1 and 2 present the outcomes of these two studies with respect to the potential for small hydropower in South Africa and the Eastern Cape respectively.

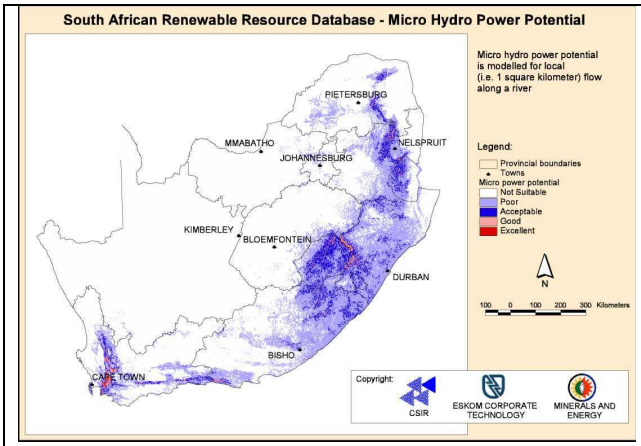

Figure 1 Micro hydro potential South Africa (Muller 1999)

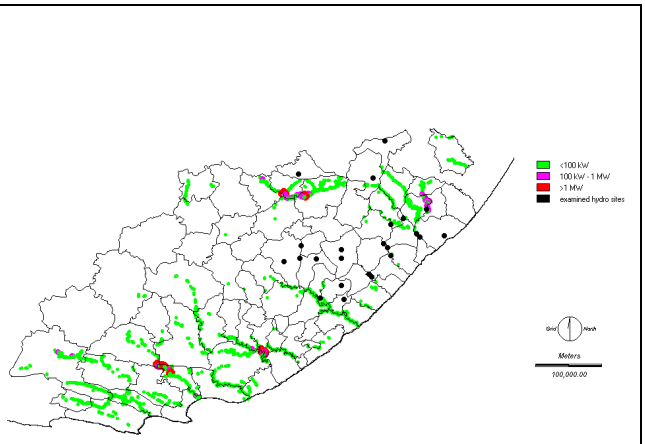

Figure 2 Small hydro potential in the Eastern Cape (Szewczuk, Fellows & van der Linden 2000)

In the "Baseline study on Hydropower in South Africa", which was developed as part of the Danish support to the South African Department of Minerals and Energy, Barta (2002) investigates the installed

capacities of hydropower in South Africa and the potential for new developments. He concludes that twice more the installed capacity of the present installed hydropower capacity below 10 MW can be developed in the rural areas of the Eastern Cape, Free State, KwaZulu Natal and Mpumalanga.

Table 1. Hydropower capacity in South Africa (Barta 2002)

Hydropower category (power output)	Installed capacity (MW)	Potential for development (MW)
Pico (< 20 kW)	0.02	0.1
Micro (20 kW to 100 kW)	0.10	0,4
Mini (100 kW to 1 MW)	8.10	5.5
Small (1 – 10 MW)	25.70	63.0
Total	33.92	69.0

2. BARRIERS TO AND SUPPORT FOR THE UPTAKE OF SMALL HYDRO

The challenges facing small hydropower exploitation in general are many and most of them are 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 small hydro, 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 pose special technical challenges.
- Lack of infrastructure for manufacturing, installation and operation. Most of the countries in Africa do not have any facility to manufacture even the most rudimentary turbines or parts that 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, detailed studies that would include detailed design and costing of the schemes to make a meaningful impact on utilisation of small hydro sites.

Through the 2003 White Paper on Renewable Energy and the recent announcement of a grid feed-in tariff for small hydro of ZAR 0.94 / kWh (NERSA 2009) the South African government has ensured that an enabling policy and regulatory framework does exist for small hydro power. Although the hydro REFIT is only applicable for grid connected systems and excludes rural off grid systems, a new government initiative called Working for Energy is being established to support rural energy provision, including small scale hydropower.

Unfortunately the current reality is that still a very limited number of new hydropower developments do take place in the country, suggesting that either the expected positive effects of the mentioned government initiatives is yet to materialise or other factors are hampering the uptake of this technology. It is therefore opportune to have a look at recent developments on the continent in relation to small hydro to see whether lessons can be learned towards sustainable implementation of projects in South Africa.

3. EXPERIENCE IN OTHER AFRICAN COUNTRIES

At the moment several initiatives are ongoing to assist developing small hydropower in Africa. A number of UN agencies like UNDP, UNEP and UNIDO are active in support programmes to remove barriers to the harnessing of the large small hydropotential, small hydro support centres are established or in the process of being established in a number of countries and a number of national rural electrification programs does include electricity generation by small hydro. Also bilateral donors and NGOs have embraced small hydropower as a means to provide energy to rural areas.

The United Nations Environment Programme (UNEP) is implementing a Global Environment Facility (GEF) funded project that looks at the possibilities of applying small hydro at tea estates to generate electricity in the Eastern Africa region. Starting from the premises that tea does need altitude and water to grow, which incidentally are requirements for hydropower as well, a collaboration of the East African Tea Trade Association (EATTA), UNEP, the African Development Bank and the GEF has set up a facility to accelerate the uptake of hydropower. The project received huge interest by the tea estates due to the current unreliable power supply from the national electricity grids. The project aims to establish 6 small hydro power demonstration projects in at least 3 of the EATTA member countries, preferably with an attached rural electrification component, as well as to prepare additional pre-feasibility studies. Both studies and planned installations will serve as training grounds for the entire tea sector in the region. The project includes a special financing window to assist individual tea processing plants to move into "green power generation". A key feature of this Greening the Tea Industry in East Africa project is linking the energy requirements of the tea industry with the available hydro resources and using this as a basis to develop viable projects that preferably do include a rural electrification component.

In West Africa the UN Development Programme (UNDP) is implementing a GEF project that will promote decentralised off-grid rural electrification in 10 countries with micro hydropower systems as a key element in creating viable rural economies. For each of the participating countries, the project intends to strengthen the institutional, regulatory and operational capacities of key agencies to provide decentralised microhydro-based electricity access to remote rural areas and it will deploy 36 hydroplants in rural areas. The lessons learned at national level will be shared amongst the 10 participating countries in order to effectively develop viable delivery models. Although still under implementation one of these lessons is the need to ensure compatibility between (pre)feasibility studies carried out and the level of detail required by potential financiers of the projects.

To create more capacity for small hydro development in Africa a number of initiatives to create knowledge and training centres are currently under way, with the inauguration of the UNIDO Regional Centre for Small Hydro Power for ECOWAS Region at Abuja, Nigeria on 22 May 2006 as a key achievement. Similar initiatives are under preparation for other African countries.

In Rwanda the Ministry of Infrastructure is financing 11 hydropower plants with installed capacities from 100 kW to 9.5 MW. Upon completion, some will be grid connected and managed by the local electrical utility, while others will be off grid and managed by local authorities through association of consumers or in the beginning by the utility or any other private company while building capacity of local associations of consumers wherever possible, although this is clearly seen as a challenge by the ministry (Karenga 2009).
The country is assisted in their efforts of building a local small hydro industry by different donor agencies. While UNIDO has followed the route of village level management of the four hydrosystems they are supporting, experience gained in implementation has forced them to revert to management models in which the systems are operated through private businesses (Ali Mohamed 2009). Contrary, the Dutch/German funded EnDev program followed a pure private sector approach from the outset. Under this program five business consortia have been contracted (out of 20 proposals received in two calls) to implement small hydro systems. Typical participants in these consortia are local business men, NGOs, social institutions (hospitals), local and foreign investors. The EnDev program provides 30-50% investment subsidy, technical assistance, business support, etc., while the developer is responsible for financial closure (15% equity and loans), construction, permits, etc. (Raats 2009).

Under the header of the EU funded project “Catalysing Modern Energy Service Delivery to Marginal Communities in Southern Africa”, the British NGO Practical Action is implementing a regional micro hydro project in Malawi, Mozambique and Zimbabwe. The project seeks to promote the use of renewable energy through creating micro hydro expertise in poor communities by equipping community members with micro hydro scheme management skills, such as installations, fabrication of equipment, etc. The project aims at the installation of 15 micro hydro units in the three countries concerned. The project is in the initial phases of its implementation and currently supports three hydro systems in different phases of implementation. The project does look into the development of a regional pool of microhydro expertise, including local manufacturing, quality standards and work on removing of political barriers. Also management and ownership models will be tested and evaluated under the project (Mika 2009).

Recent evaluation of existing small hydro systems in Tanzania (Jonker Klunne, Michael 2009) does suggest that village level small scale hydrostations are best managed in a business-like fashion, although it also concludes that community engagement/involvement is crucial in all phases of the hydro site development.

4. CONCLUSIONS

Although South Africa has a substantial potential for small hydropower development, particular in the rural areas of the Eastern Cape, Free State, KwaZulu Natal and Mpumalanga, at the moment only very few stations are in operation. With the current target of 10,000 GWh of electricity generated by renewable energy sources by the year 2013 as mentioned in the 2003 White Paper on Renewable Energy, the announcement of a feed in tariff for mini hydropower, the initiation of the Working for Energy program, the current government priority on rural development as well as international support offered to the country, the time is ripe for the development of more small hydropower stations to provide currently unserved rural areas with electricity.

Several initiatives are currently ongoing on the continent from which South Africa can draw valuable lessons with respect to sustainable implementation of such systems. Hydropower development needs to be embedded in a national program for capacity building and industrial development to foster a new industry to emerge. Particular attention needs to be given to governance issues related to hydro stations as experience from other countries suggests that linkages with ongoing economic activities will ensure proper management of the system. Also the inclusion of entrepreneurs / private sector developers could benefit the sustainability of the systems.

It is proposed that a national task team will be set up to ensure coordination between the different stakeholders and linkages with other developments in the region. Parallel to this it is suggested that research into appropriate implementation modalities is initiated to ensure that the enabling environment that is created for the implementation of renewable energy technologies will result in small hydropower systems that are implemented in a sustainable fashion to bring the highly needed energy services to rural areas of the country.

5. REFERENCES

Ali Mohamed, F. 2009, "Rural electrification - Rwanda case study", *Hydro Africa 2009 conference, 28 & 29 July 2009, Johannesburg*.

Barta, B. 2002, *Capacity building in energy efficiency and renewable energy. Baseline study - hydropower in South Africa*, Pretoria.

ESKOM 2003, , *Sabie River Power Station*. Available: http://www.eskom.co.za/heritage/sabie/sabie.htm [2003, 13 December] .

Jonker Klunne, W. 2007, *Small hydropower development in Africa*.

Jonker Klunne, W. & Michael, E.G. 2009, "Increasing sustainability of rural community electricity schemes – case study of small hydropower in Tanzania", *SET2009 8th International Conference on Sustainable Energy Technologies, Aachen, Germany, August 31 - September 2009*.

Karenga, E. 2009, *Small hydropower development in Rwanda*.

Klunne, W. 1993, *Hydro-power end-uses at Svinurayi co-operative (Cashel Valley, Eastern Highlands, Zimbabwe)*, University of Twente, Enschede, the Netherlands.

Mika, L. 2009, "Village hydro in Malawi, Mozambique and Zimbabwe", *Hydro Africa 2009 conference, 28 & 29 July 2009, Johannesburg*.

Mtalo, F. 2005, *Small scale hydropower for rural development*, Nile Basin Capacity Building Network NBCBN Research cluster.

Muller, J. 1999, *South African renewable energy resource database. Chapter 2 Modelling hydro power potential*, CSIR, Pretoria.

NERSA 2009, *NERSA decision on renewable energy feed-in tariff (REFIT)*, NERSA, Pretoria.

Raats, M. 2009, "Business models for (MHP) village grids - two EnDev case studies -", *Africa Electrification Initiative inception workshop, June 2009, Maputo*.

Szewczuk, S., Fellows, A. & van der Linden, N. 2000, *Renewable energy for rural electrification in South Africa*, European Commission FP5 Joule-Thermie Programme.