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Current status and future developments of small and micro hydro in southern Africa

Wim Jonker Klunne
Council for Scientific and Industrial Research (CSIR)
PO Box 395
Pretoria 0001
South Africa

Introduction

Small and micro hydropower are renewable energy technologies that have large potential in the southern African region, both for grid and off-grid applications.

Within the region a good understanding exists on the potential for large scale hydro with a substantial number of plants in operation and under development. Small and micro hydropower are less well understood.

Historically small hydropower has played an important role in the development of the region, but since mid 1960s the emphasis has been mainly on fossil fuel based electricity generation. Only recently small and microhydro power are getting attention again from developers and policy makers.

The article will investigate the different barriers in southern Africa toward (rural) electrification and the application of renewable energy technologies in general and to those hampering the uptake of small hydropower in particular. The article will describe the role of policy and regulatory frameworks, financing, local and regional human and industrial capacity, as well as the limited information available on the resource.

The article will provide an overview of current developments in the different countries of the region, including the installed small and microhydro capacity and ongoing activities to increase this.

Based on the analysis of country level and regional activities to promote the uptake of small and microhydro, the article will draw conclusions and provide recommendations towards large scale implementation of small and microhydro power in southern Africa.

1 Background

Approximately 10% of the global hydropower potential is located on the African continent, with the majority of that in Sub-Saharan Africa. However, only a low 4 to 7% of this potential has been developed [1,2].

Normally hydropower potential figures stated are referring to large scale hydropower only. For the African continent no proper statistics are available on the potential for small and micro scale hydropower. Common understanding is that the rate of development of small and micro hydro is even lower than for large scale hydropower. An indication of the low rate of small hydropower development on the African continent was given by Gaul et al. [3] by comparing the 45,000 plants below 10 MW in China with a total of a few hundred developed sites in the whole of Africa indentified by them. The European Small Hydropower Association [1] is even referring to 100,000 units in the micro spectrum as installed in China!

Small hydropower can play a pivotal role in providing energy access to remote areas in Africa, either in stand-alone isolated mini grids or as distributed generation in national grids. The potential role of small hydropower in eradicating energy poverty has been recognized by a number of national governments and bi- and multilateral donors. An example is the new draft energy strategy for the World Bank, which does specifically highlight small scale hydropower as an important component of future World Bank activities in Africa [4]

The large knowledge base on technical aspects of microhydro in general does suggest a proper understanding of the technology. However, the relatively small number of small and micro hydropower projects implemented in Africa does not reflect the enormous potential for the technology on the continent, suggesting that other barriers than the technology itself are still persistent.

Although small hydropower projects have been implemented in several countries on the continent, information on the current state of affairs is scattered and incomplete. To a (very) limited extend information is available on technical details of implemented projects, however, information on implementation models followed and their successfulness is not available in most cases [5,6]. Basic technical information on existing hydrostations might be available, but is definitely not complete nor consistent over the different information sources. This lack of information does severely hamper the possibility to learn from past experiences and is a barrier to large uptake of small and micro level hydro on the continent [3].

2 Defining small and micro hydropower

At this stage no internationally agreed definitions of the different hydro sizes exist. A generic distinction though is between "large" hydro and "small" hydro. The most generally accepted definition of "small" has been set by the World Commission on Dams, which set the upper limit for small hydro at 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. Recently some international donors seem to use a maximum capacity of 15 MW when referring to small hydro.

Within the range of small hydro, distinction can be made between mini hydro (often limited to an installed capacity of maximum 1 MW), micro hydro (below 300 or 100 kW depending on the definition) and pico hydro (below 20, 10 or 5 kW), each with its own specific technical characteristics. Micro and pico hydro installations are mostly found 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 for example heavy access roads for delivery of materials and electro-mechanical equipment.

In this article the upper limit of 10 MW of installed capacity is being used when referring to small hydropower, while microhydro is defined as installations below 300 kW of installed capacity (in line with [7]).

3 Small and micro hydropower in southern Africa

Small hydropower is a proven, mature technology with a long track record, also in Africa. The gold mines at Pilgrims' Rest (South Africa), for example, were powered by two 6 kW hydro turbines as early as 1892, complemented by a 45 kW turbine in 1894 to power the first electrical railway [8]. In several southern African countries church missions did build small hydropower installations, like in Tanzania where church missions installed more than 16 small hydropower systems during the 1960s and 70s that are still operating [9]. Another example is large scale commercial farmers in the Eastern Highlands of Zimbabwe that installed hydro stations as early as the 1930s [10].

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, some because a lack of maintenance or even pure neglect.

Recently initiatives have seen the light in a number of countries in Africa to revive the small hydro sector, either through international development agencies or through private sector led initiatives. Particular in Central Africa (Rwanda), East Africa (Kenya, Tanzania and Uganda) as well as Southern Africa (Malawi, Mozambique and Zimbabwe) new initiatives are focusing on implementing small hydropower projects. In South Africa the first new small hydro station in 20 years was opened in 2009, with more under development.

4 Barriers

Most of the challenges facing small hydropower exploitation are not specific to hydropower but generic for all types of renewable energy and rural electrification projects. General barriers for renewable energy projects are the absence of clear policies on renewable energy, limited available budget to create an enabling environment for mobilising resources and encouraging private sector investment, and the absence of long-term implementation models that ensure delivery of renewable energy to customers at affordable prices while ensuring that the industry remains sustainable.

Looking specifically at small hydropower development, the following barriers can be identified:

- **Policy and regulatory framework**: unclear or non existence of policies and regulations that govern the development of (small) hydropower. In some countries hydropower developments under a certain threshold are not regulated at all, while in other countries it might be part of a broader regulatory framework for rural electrification in general. Generic frameworks often lack clarity on a number of hydropower specific issues like access to water and water infrastructure and the associated payments.
- **Financing**: hydropower developments are faced, even more than other sources of renewable energy, with high up-front costs and low O&M costs, something most available financing models do not favour. Nearly all of the new developments on the continent are relying in one form or the other on donor financing. Development of alternative financing models, including tapping into alternative funding sources, is needed to facilitate small hydro developments.
- **Capacity to plan, build and operate hydropower plants**: national and regional knowledge and awareness on the potential of small hydro in rural electrification is missing or very minimal. This includes knowledge at political, government and regulatory entities, as well as knowledge on local production of parts and components.
- **Data on hydro resources**: linked to the limited knowledge about the technology is the lack of proper resource data on water availability and flow on which hydro developments can be based.

Regulatory and legislative frameworks

A clear prerequisite for the uptake of small hydropower are policies and strategies that are in support of small scale renewable energy development. These should show long-term vision, as well as concrete targets and implementation plans with associated budget allocations. Preferably they include coordination efforts on support by international donors.

Unfortunately, in Africa very few countries have been able to develop such strategies and policies. Although almost all Sub-Saharan African countries have rural electrification plans, their main focus is on grid extension and most of them do not address renewable energies, let alone specifically support small hydropower deployment.

The availability of long-term grid extension plans is essential to enable small hydro investor to assess financial project viability. Grid extension plans can provide the needed information on whether an area will see grid extension and thus whether the set-up of an independent mini-grid will be viable. More often than not the national electricity grid reaching an isolated small hydroplant has resulted in the hydroplant being decommissioned and the community being connected to the national grid. Only very few examples exist where an existing small hydro station is being integrated in the national grid (e.g. Mantsonyane in Lesotho) or is able to operate in parallel to it (e.g. Matembwe in Tanzania).

Next to the needed regulation and legislation with respect to the electricity aspects of small hydropower, rules and regulations with respect to water use and use of physical water infrastructure are essential in developing small hydropower.

Funding of hydropower schemes

Three broad categories of funding of small hydropower developments can be distinguished:

- **Private or balance sheet funding** for systems that serve one household / farm or are part of the operations of a commercial enterprise. These systems tend to be designed to supply a small load consisting of domestic energy use and more power demanding applications like milling or grinding. As these systems do typically not supply outside entities their existence is quite often not publicly known and information is rather difficult to get. Funding of these systems normally does not involve external parties. A typical example is the Horseshoe Falls system in Sabie in South Africa, which was designed and built by farmer Pieter Weber in the 1960s and operated till 1990 when the national grid reached the farm [11]. Another example was the use of hydropower at the Havelock Asbestos mine in Swaziland.

- **Public funding**, often through the national or municipal power utilities, for grid connected systems. This typically involves larger systems like the 2 MW Mantsonyane plant in Lesotho. Specific funding could be available for off-grid installations through Rural Electrification Agencies and Rural Electrification Funds.

- **Systems funded by bilateral donors** and multilateral donors. These systems will often form part of a national programme on energy access / rural electrification.

Financial incentives for hydropower systems can be provided through generation based incentives or installed capacity based incentives.

The best known example of the generation based incentives are renewable energy feed-in tariffs, which do pay owners of renewable energy generators a premium based electricity tariff. In southern Africa, only South Africa did have a specific feed in tariff for hydro power (see details in 5.3).

Capacity based incentives do provide up front funding to offset the high investment needed for hydropower and are typically modelled as once-off investment subsidies. Particularly for off-grid systems capital investment support is considered a preferred form of support as long as it is supplemented by a business model to operate the facility in a sustainable way. This support can be given in the form of grants and loans, or as tax incentives on the investment.

A specific form of financing is provided by the Clean Development Mechanism (CDM) under the Kyoto protocol. Most of the hydropower projects world-wide that benefit from CDM funding related to avoided carbon emissions are in Asia (India and China) while only four can be found in southern Africa[1] [12]. The uncertainties around the CDM funding after the end of the Kyoto protocol in 2012 make investors hesitant to follow this route. Coupled with a general lack of CDM project development capacity in Africa it is not likely that the number of CDM funded projects will increase dramatically in the (near) future.

Linked to the carbon emissions avoided tradable renewable energy certificates can be issued for hydropower plants, which can provide an additional revenue stream for the operator. At the moment only South Africa has an operational system for tradable RECs in place in Africa. The South African RECs initiative has the 3 MW Friedenheim plant in Nelspruit as one of its contributors [13].

[1] Tsiazompaniry and Sahanivotry in Madagascar and Clanwilliam and Bethlehem in South Africa

Table 1 Support for renewable energy [14]

Country	Feed in tariff	Tradable REC	Capital subsidy	nvestment / production tax credits	Reduction in sales tax	Public Investment Loans / grants	Public competitive bidding	Rural electrification agency
Botswana					X			X
Lesotho						X		X[2]
Malawi								X[3]
Mozambique						X		X
South Africa		X	X				X	
Zambia					X			X
Zimbabwe								X

Capacity building

Local capacity to plan, design, build, operate and maintain hydroplants is essential towards the successful operation of small hydropower in Africa. Without proper resource assessments and associated feasibility studies no project will be developed. Similar, without proper maintenance and technical capabilities to repair systems, sustainable operation will not be possible.

National and regional capacity to plan and design systems has been and currently is being build by (international) NGOs funded by development assistance funds from developed countries. Also local production of turbines and other components of hydroplants has been piloted by in particular Practical Action, but with the limited regional market these efforts have not resulted in wide spread local production.

In an analysis of best practices on microhydro developments, including detailed descriptions of four installations on the African continent, Khennas and Barnett [15] pointed out that the lack of knowledge about financial management and utilisation of electricity to generate revenues is a main bottleneck for a successful operation in Sub-Saharan Africa.

The limited number of microhydro projects in Africa has resulted in few people with practical experience in the technologies involved. Gaul et al. [3] identify four approaches to address this deficit:

- Establish international or regional knowledge networks and induce foreign expertise by training local technicians.
- Strengthen technical schools and science institutes to build up local capacity.
- Project-driven approach, involving local engineers in the planning and implementation of projects and at the same time building up their skills.
- Technology transfer either north – south or south – south. Particular the small hydro expertise in countries like Nepal and Indonesia could be targeted for technology transfer.

GIZ is currently pursuing the establishment of a training and knowledge centre on small hydropower in Chimoio, Mozambique. The centre will initially focus at local level capacity building, but eventually expand to a regional focus [16].

[2] GEF project
[3] Bilateral project

5 Current status

This chapter will give an overview of the current status of small and micro hydropower in selected countries in the southern African region.

5.1 Lesotho

All locally generated electricity is hydropower based, with the 72 MW 'Muela plant providing most of it, currently only augmented by two mini hydro plants. The Lesotho Highlands Water project does offer opportunities for more hydropower developments and several studies have been conducted on possible pumped-storage plants as well.

It is estimated that the large scale hydro generation potential for Lesotho is approximately 450 MW. The potential for small-scale hydropower plants in Lesotho has been investigated in a number of studies. By 1990 a total capacity of 20 MW had been identified at 22 sites for both mini and micro hydro [17]. In the range of 100 to 1000 kW the French company Sogreah (nowadays part of Artelia) has studied nine potential sites and completed feasibility studies on three preferred sites: Tlokoeng, Motete and Qacha's Neck. In the micro range of hydropower a report by NERCA [18] estimates a potential of between 20 to 40 feasible sites in the country with an average capacity of 25 kW.

At the moment the country has 5 small scale hydroplants, namely Mantsonyane (2 MW), Katse (570 kW), Tsoelike (400 kW), Tlokoeng (670 kW) and Semonkong (180 kW). Out of these five only Katse and Semonkong are currently operational[4].

Taele et all [17] summarise the current situation for small hydropower very effectively in their recent article in Renewable Energy: "The environment is presently conducive for development of small hydropower systems in the country. First the country has adequate hydro resources. The settlement pattern of the country in the rural areas favours decentralised systems of which small hydropower is one of the viable means of improving access to electricity. The present legislation allows for independent power producers/distributors to operate in the county therefore there is no threat to International Partners willing to operate small hydropower plants. One of the duties of the regulator is to relax the standards slightly for rural electrification projects. This will lower the costs of providing electricity in the rural areas. Very soon, the National Rural Electrification Fund will be up and running. This will supplement the capital requirements for new projects."

However, the reality on the ground has proven to be difficult for international partners to find viable business models for the development of small hydropower in Lesotho. Tarini Hydro Power Lesotho Ltd., a subsidiary of Tarini in India has been trying for a couple of years now to get two hydro projects off the ground (the 80 MW Oxbow plant and the 15 MW Quithing project) but still has not been able to get construction started.

5.2 Mozambique

The country's greatest hydro potential lies in the Zambezi River basin at sites such as Cahora Bassa North and Mphanda Nkuwa. So far, about 2,200 MW of generating capacity has been developed. In addition, the potential for small hydropower projects is 190 MW, which includes 6 MW of micro hydro (defined as smaller than 2 MW), 18 MW of mini hydro (size between 2 and 6 MW) and 166 MW of small hydro (between 8 and 15 MW). Potential sites for these micro hydropower schemes are located in the mountainous terrain and perennial streams and rivers of Manica, Tete and Niassa provinces [19].

[4] The Mantsonyane power station was flooded with water in the beginning of November 2006 and out of operation since then. The floods lasted throughout the three day period 3rd to 5th November, 2006 and saw the powerhouse fully inundated [47]. Currently LEC is in the process of rehabilitating the power station as part of the African Development Bank's "Lesotho Electricity Supply Project". A tender process in this respect has been started in the second half of 2011 [48].

The study on medium-sized and large plants reveals that the potential is very high in the central (Sofala, Manica and Zambézia provinces) and northern (Nampula, Cabo Delgado and Niassa provinces) parts of the country. The south (Maputo, Gaza and Inhambane provinces) is relatively poor in hydro resources for energy generation. The tea-producing areas, which are concentrated in the districts of Gurue, Ile, Milange and Lugela in Zambézia Province, also have very good hydro energy resources, according to an energy survey undertaken by the National Energy Fund (FUNAE) in 2004. An ITDG [15] publication gives an overview of micro hydro potential in Mozambique, especially in Manica Province, while a scoping study for micro hydro investments in the provinces of Manica, Niassa and Tete undertaken by ITDG for the ERAP project of the World Bank, identifies the critical issues in developing the hydro sector[20].

In the Policy for Renewable Energy and Master Plan for Off-Grid electrification [21] a list of 60 identified hydropower locations is provided. The Department of Energy estimates that over 60 potential micro- and mini-hydropower projects with a potential of up to 1,000 MW exist in the country. The central part of the country (Manica Province) has the best resources. Table 2 provides a summary of priority Government projects.[22]

Table 2 Summary of Government hydropower projects [22]

Project	Installed capacity (kW)	River	Prefeasibility done?	Distance to the nearest village (km)	Location (District, Province)
Mbahu	2000	Lucheringo	Yes	30	Lichinga, Niassa
Majaua	1000	Majaua	Yes		Milange, Zambezia
Kazula	30	Lazula	Yes	~12	Chiuta, Tete
Maue	280	Maue	Yes	~1	Angonia, Tete
Mavonde	30	Nhamukwarara		3	Manica,Manica
Rotanda	30	Rotanda	Yes	~1.5	Sussundenga, Manica
Sembezeia	30	Bonde		2	Sussundenga, Manica
Honde	75	Mussambizi	Yes	4	Barue, Manica
Choa	20	Nhamutsawa		~2.5	Barue, Manica

Next to the national government of Mozambique a number of NGOs and bi-lateral donors are active in the micro hydropower field in the country. Practical Action together with their Mozambican counterpart Kwaedza Sumukai Manica (KSM) is developing village electrification projects following what they call the “generator model”. This model is build around a private entrepreneur generating electricity for the community, while the local transmission and distribution infrastructure will be owned by the community [23].

German GIZ has also worked with local entrepreneurs to extend their business from milling to local electricity distribution and has upgraded three systems [24-26], supported local production of turbines and is currently assisting local education institutes in Chimoio, Manica province, to set up a local hydropower training and knowledge centre [16].

5.3 South Africa

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 [27] 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. In a later publication Barta [28] does include new insights in the potential of small hydropower in South Africa by including the hydro potential of water transfer systems and gravity fed water system and mentions a total potential of 247 MW of which 38 MW has been developed.

Currently approximately 42 MW of small scale hydropower is in operation in South Africa [29], while a number of plants are currently in advance stages of development. Examples of the plants in operation are the Friedenheim hydro station (2 MW) in Nelspruit that supplies electricity to the local municipality under a PPA, the Lydenburg hydro plant (2.6 MW), which is owned by the Thaba Chweu Local Municipality and operated on their behalf by a private operator and the recently commissioned Bethlehem hydro station. In the micro range a substantial number of systems is in operation in the KwaZulu Natal and Eastern Cape region, primarily supplying individual farmers.

Next to the operational plants, South Africa has a few existing small scale installations that are currently not in operation but could be refurbished to working order, like Belvedere (2.2 MW), Hartbeespoort (37 kW) and others [28].

Government support for renewable energy is governed through the 2003 Renewable Energy White paper, which sets a target of by 10 000 GWh of renewable energy to be achieved by 2013 [30]. No specific targets were set in this White Paper for the different renewable energy technologies and very little has been done to ensure the country will reach this target. An update process for the White Pare was started in 2009 with support of the DBSA and World Bank, but has not resulted in an updated White Paper and/or target.

In 2010 the Department of Energy presented the Integrated Resource Plan (IRP2010), outlining the electricity generation mix for the period up to 2030. According to the policy adjusted development plan that was approved by cabinet, the country will see 17.8 GW of renewable energy as part of the energy mix in 2030. The main source of hydropower in the IRP2010 will come from imported electricity (approx. 5.2 GW by 2030), while local, small scale hydropower shares an allocation of 125 MW with landfill gas based electricity [31].

In March 2009 the energy regulator (NERSA) announced Renewable Energy Feed-In Tariffs (REFIT) for a selected number of renewable energy technologies. Small scale hydropower (between 1 and 10 MW) qualified for a REFIT of ZAR 0.94/kWh (approx. € 0.074 / US$ 0.096) [32]. However, unclarity around the legal status of the REFIT and who would be the buyer of the electricity produced prevented PPAs from being signed for this tariff. The REFIT review in 2011 did see adjustments in the REFITs based on adjusted figures for inflation, costs of capital and other assumptions. The REFIT for small hydro power was revised downwards with more than 28% to ZAR 0.671/kWh (approx. € 0.065 / US$ 0.089) [33].

During the same time as the REFIT review, the South African government announced its intention to start a competitive bidding process for renewably generated electricity. Initially it was understood that the bidding process would focus on non-price criteria as local content, project readiness, job creation potential etc., with the price set according to the REFIT rates. However, when the Request for Proposals was issued in August 2011, it became clear that the bids would be evaluated on a two-stage procurement evaluation process that includes qualifying criteria based on economic development requirements, as well as price. This effectively side tracked the REFIT process [34]. In the Renewable Energy Independent Power Producer Procurement Programme a total of 3 725 MW is to be procured by Government, with an allocation of 75 MW for small hydropower [35]. The bidding process will see a number of bidding rounds, of which the first has been concluded with allocation of 1415 MW to a total of 28 bidders, none of which involves hydropower [36]. Currently the second bidding round has been closed and the bids received are under review. Depending on the number of MWs that will be allocated under the second round, more rounds will follow. For small scale projects of less than 5 MW, a special small scale projects window will be launched in the near future, which might give better opportunities for small hydro.

5.4 Swaziland

Several studies have been done to estimate the hydropower potential of Swaziland. In 1970, the UNDP financed a study by Engineering and Power Development Consultants which identified 21 possible sites for hydropower schemes [37]. While based on existing information the Environmental Centre for

Swaziland [38] comes to a gross theoretical potential of 440 MW and a technically exploitable potential of 110 MW of which 61 MW is economically exploitable.

The latest full study on hydropower potential in Swaziland was carried out by Knight Piesold Consulting in 2001 [39]. The study showed that there are a number of micro (<0.1 MW), mini (0.1–2.0 MW) and small (2–10 MW) hydropower generating sites along the rivers in the country. The available potential for both micro and mini hydropower is about 8 MW.

Currently only 5 hydro stations are operational in the country: two in the small hydro range and three in the large hydro range. The Swaziland Electricity Company (SEC) is operating the grid connected Ezulwini (20 MW), Edwaleni (15 MW), Maguduza (5.6 MW) and the Maguga (19.5 MW) installations. The small scale Mbabane station of 500 kW was decommissioned by SEC in December 2010 as it was not longer able to operate this 1954 hydro station profitably [40].
Although a 1987 UNDP / ESMAP study on the energy sector in Swaziland identified a total of approximately 1 MW of non-utility hydro generation capacity in the country [37], it appears that only the 800 kW system of Swaziland plantations is still in operation [41].

At the moment feasibility studies are ongoing for the Ngwempisi cascading scheme that is expected to have a total installed capacity of 120 MW over three different sites [42], while at least one owner of an old defunct hydrostation of 50 kW just outside Mbabane is considering rehabilitation.

5.5 Zimbabwe

The total hydropower potential on Zambezi River for Zimbabwe and Zambia is 7200MW. Of this 750 MW each has already developed at Lake Kariba. A further 4200 MW that can be developed jointly with Zambia on Kariba Extension (at least 1500 MW), Batoka Gorge, Mupata Gorge and Devils Gorge. There is a potential to generate 120 MW from small and mini-hydropower resources (20 MW from existing dams, 60 MW from proposed dams and 43 MW from run-of-river sites) [43].

One small hydroplant of 800 kW at Rusito in the Chimanimani area is connected to the national grid and has a PPA with the national utility ZESA. Other small hydroplants are installed at Kwenda (80 kW), Sithole-Chikate (30 kW), Svinurai (20 kW), Mutsikira (10 kW), Rusitu (700 kW), Nyafaru (40 kW), Aberfoyle (30 kW) and Claremont (250 kW) [44].

Recently the Masvingo Rural District Council has approved a US$ 13 million 5 MW small hydro power project at Lake Mutirikwi. The application was made by the Great Zimbabwe Hydro-Power Company, which is jointly owned by a Zimbabwean company, ZOL and its South African partner, New Planet. The plant is one of two currently being developed by Zimbabwe. Another 5 MW facility at Tokwe-Murkosi is planned for completion in 2013 [45].

Detailed plans do exist for the Manyuchi dam hydro plant. ZESA has long had plans to generate electricity from the dam but nothing has come of it due to shortage of funding. Studies show, however, that the water availability should make it possible to drive two 350-kilowatt turbines 6 000 hours per year, so as to generate 4.2 GWh per year [46].

6 Conclusions

Small and micro hydropower were once very prominent in the electricity generation of countries in southern Africa, but have seen a drastic decline in their numbers of the last decades. Although a number of barriers towards to the uptake of the technology persist, renewed interested in the technology has resulted in a number of new projects being initiated.

At the moment a lack of information on projects operating and under development does hamper the uptake of the technology and limits the understanding of the role of small hydropower in the development of the region. Ongoing research is needed to make the implementation of the technology better suited to the region.

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Author

Wim Jonker Klunne, a renowned microhydro expert 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. He has an academic background in Civil Engineering and Management with specialisation into small and micro hydropower in Africa.

Currently Wim is working at the Council for Scientific and Industrial Research (CSIR) in South Africa as senior researcher Renewable Energy & Energy Efficiency. One of his research projects is looking at the sustainability of microhydro projects in Eastern and Southern Africa.

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