Empowering the Kwa-Madiba community

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INTRODUCTION

The electrification of urban areas in South Africa, including many informal settlements, reached its culmination during recent years. However, the electrification of rural areas still has a long way to go before most of the rural communities will be provided with a reliable and sustainable electricity supply. The national electricity grid, managed by the parastatal ESKOM, has been experiencing problems due to various reasons, particularly since 2008. The further development of rural electrification is currently on the backburner, mainly due to the shortage in the generation capacity available to ESKOM, which needs to be made available to the users already connected to the national grid. The increases in the price of electricity are starting to be felt by urban and rural communities alike. The primary electricity infrastructure (coal-fired power stations, major supply lines and distribution of electricity within urban areas) is rapidly becoming insufficient and cannot sustain a supply against the demand for electricity from the existing and future users connected to the national grid.

The potential electricity users in the rural areas of primarily the Eastern Cape and KwaZulu-Natal will have to wait until ESKOM, as the national utility, is able to increase its margin between the supply and demand generation capacities, and satisfy delayed electrification expansion development of those users already connected.

Small hydropower schemes can play a critical role in providing energy access to remote areas in South Africa as stand-alone, isolated mini grids (Van Dijk *et al* 2014). Internationally, small hydro is considered to be the best proven renewable energy technology, ideal for the electrification of remote communities (Loots *et al* 2014).

Rural electrification is the provision of long-term, reliable and satisfactory electricity service to households in remote rural communities via grid or decentralised/centralised, renewable/non-renewable energy resource. Many consider electrification as a fundamental strategy for poverty alleviation in terms of financial, energy and sustainable developments (Bagdadee 2014), and rural electrification has the potential to improve the standard of living of people in a developing country such as South Africa. However, universal access to modern forms of energy is still far from being a reality in many parts of South Africa, due to their remoteness, sparse population and relatively low average energy demands. With 80% of the urban areas and 45% of the rural areas electrified, the emphasis of the South African electrification programme is shifting from the urban to the rural areas of South Africa. Where feasible, grid electricity will be extended as far as possible into the rural areas, but large numbers of households and communities will not be connected to the national electricity grid for the foreseeable future.

Alternative, energy technologies would need to be developed and implemented to ensure that the South African government's objective of universal access to energy and electricity for all its citizens is achieved (Szewczuk *et al* 2000).

BACKGROUND

In July 2011 the South African Cabinet unveiled 12 implementation plans for immediate action by government. Action Plan 6 called for "scaling up rural development programmes, including investment in rural areas and the revitalisation of smaller towns". Responsibility for implementing Action Plan 6 was given to the Department of Rural Development and Land Reform (DRDLR) in conjunction with the Presidency. The DRDLR took immediate action and by September 2011 had initiated a programme which focused on people living in 23 distressed municipal districts. These areas are home to almost 18 million of South Africa's rural residents, many of whom are living in poverty (DRDLR 2013).

The Department of Science and Technology (DST) aims at piloting a range of innovative technology solutions to enhance service delivery through an initiative called the Innovation Partnership for Rural Development (IPRD) programme. The IPRD programme is an initiative of the DST aimed at value addition to the targeted 23 district municipalities in response to some of their prioritised needs (DST 2013).

The DST is the lead agency steering the IPRD initiative in close cooperation with local municipalities, the Department of Cooperative Governance and Traditional Affairs, and the Department of Rural Development and Land Reform. The DST has contracted two implementation agencies, one of which is the Water Research Commission (WRC), to showcase and test a suite of water, sanitation, micro-hydroelectric power and smart geyser technology solutions at municipal demonstration sites.

The WRC contracted the Water Division of the Civil Engineering Department at the University of Pretoria to conduct research within the IPRD Programme on building capacity for the implementation of small-scale hydropower (SSHP) development for rural electrification in South Africa.

One of the study areas within the targeted 23 district municipalities is the OR Tambo District Municipality (DM) in the Eastern Cape. For the initial identification of potential sites for SSHP generation within the OR Tambo DM, a desktop study was done. The focus of the desktop study was to preliminarily identify sites based solely on potential head and flow.

The different rivers and river sections within the OR Tambo DM were investigated to find height differences which would be suitable for SSHP generation. Height differences were verified by site investigations and physical measurements. Sites with a higher potential head difference initially gained preference over sites with higher flows, due to the increase in cost of larger equipment necessary to convey the larger flows.

The geometrical layout of the Thina Falls in the Thina River (Figure 1) within the Mhlontlo Local Municipality, as well as the relatively high perennial flows within the Thina River, offers a feasible opportunity for SSHP development. The total theoretical hydropower generation at the Thina Falls, utilising all the flow present in the river 95% of the time, and incorporating the total height difference between the upstream and downstream levels of the Thina Falls, amounts to 350 kW. This potential reaches megawatts when higher flows are utilised within higher flow periods.

PROPOSED HYDROPOWER PLANT

The Kwa-Madiba SSHP scheme was designed as a run-of-river scheme on the Thina River, which, as mentioned above, falls within the Mhlontlo Local Municipality in the OR Tambo District Municipality of the Eastern Cape. The intake is located at the top of the Thina Falls, and the turbine room and tailrace at the bottom of the Thina Falls. The intake and the turbine room are connected by a 42 m x 355 mm diameter intake pipeline

Figure 1: Google Earth view of the Thina Falls and the Thina River in the Eastern Cape

Table 1: Kwa-Madiba SSHP scheme technical data

Design flow rate	150 ℓ/s
Design head	48.8 m
Design power output	50.0 kW
Total penstock length	158 m
Transmission line length	1 140 m
Number of households	39

and a 116 m x 355 mm diameter penstock constructed through directional drilling. Table 1 summarises the technical data of the Kwa-Madiba SSHP scheme.

The infrastructure components of the Kwa-Madiba SSHP scheme are categorised into three sections, which can be summarised as follows:

- **Civil components**
  - Intake with primary screen and cleaning rack
  - 42 m x 355 mm Class 6 HDPE intake pipeline
  - 116 m x 355 mm Class 6 HDPE penstock
  - 6 m containerised turbine room
  - Tailrace
- **Electro-mechanical components**
  - IREM ECOWATT micro hydroelectric power plant type TBS 3-0.5
  - BANKI turbine horizontal axis in AISI 304 stainless steel mod.3-0.5 (Figure 2)
  - three-phase synchronous 4-pole generator-type AS60
- **Electrical components**
  - 1 140 m transmission lines
  - 1 000 m distribution lines.

A similar Banki turbine was installed at Bloemwater's Brandkop Reservoir, where 350 ℓ/s of water supplied to the Brandkop Reservoir via the Caledon–Bloemfontein pipeline are diverted through the turbine to generate 96 kW of electricity (Van Dijk *et al* 2015). Figure 3 shows the installation of the Banki turbine at Brandkop, while Figure 4 shows the planned layout of the Kwa-Madiba SSHP plant from intake to turbine room.

The 2011 Census showed that there are 117 households within the Kwa-Madiba rural settlement, although the actual number of households, according to observations during the site visit, were only approximately 39. The Kwa-Madiba/Thina Falls potential hydropower site will have minimal impact on the environment, due to the fact that (a) only small amounts of flow will be rerouted through the directionally-drilled penstock for hydropower generation, (b) the technology is for non-consumptive use of water, and (c) no scouring will occur due to the operation of the plant. Small amounts of flow are sufficient due to the high available head difference at the Thina Falls.

The introduction of electricity to these 39 households will impact positively on the community, particularly with the added possibility of having a pump connected to the electrical supply for pumping raw water to this community of subsistence farmers to irrigate their crops. To date four undergraduate and three postgraduate students were employed part-time on the project, and approximately thirty part-time jobs will be created by the construction of the project. In addition, two community members will be trained as full-time operators of the Kwa-Madiba SSHP plant. Figure 5 shows a few members of the Kwa-Madiba community with the investigating team at the downstream side of the Thina Falls.

The designs of the Kwa-Madiba SSHP plant have been given the green light by the funders, as well as the Local and District Municipalities, and a Water Use Licence Application (WULA) has been submitted. Upon approval of the WULA, construction of the Kwa-Madiba SSHP plant will commence.

CHALLENGES

Some of the major challenges which the project team will have to face include:

- Obtaining planned future electricity grid information from the electricity service providers (ESPs)
- The identification of land ownership and development rights
- The initial identification of potential sites to be developed.

Furthermore, a lack of historical flow data for several rivers within the study focus area necessitates the extensive capturing of flow data over a sufficient period of time in order to predict the power-generating potential at certain sites. Due to time and budget constraints, only rivers with sufficient historical flow data records were included in the initial desktop study. However, this approach could result in identifying and developing sites with technically and economically less potential than possible better sites which were unable to be identified due to historical data constraints.

The accessibility of potential SSHP sites within the study focus area was a challenge, not only to be able to visit identified sites and verify desktop study calculations with physical measurements, but also to find sites which would be sufficiently accessible to allow the physical construction of SSHPs.

On the financial side of matters, the continued poor performance of the South African currency, combined with a shortage of local turbine manufacturers and taxation on imported turbines (mainly from Europe), impacts negatively on project costs, resulting in a 30% increase in the envisaged cost of electro-mechanical equipment at certain sites. In addition, the long lead times for obtaining approvals, and the immense number of role-players and stakeholders involved, further complicate matters and add to the financial difficulties.

A lack of procedural and regulatory legislation pertaining specifically to small-scale hydropower causes the project to be subject to the same basic regulations as other electricity and water resource ventures, i.e. Water Use Licence Applications (WULAs). This could prolong the project completion time, as well as further increase project costs.

OUTCOMES

The following outcomes and results were obtained from the research on the project thus far:


Figure 2: Banki turbine and synchronous generator (IREM)


Figure 3: Banki turbine installation at Bloemwater's Brandkop Reservoir

Figure 4: Google Earth view of the Kwa-Madiba SSHP plant layout


Figure 5: Kwa-Madiba site visit downstream of the Thina Falls

- Small-scale hydropower is a feasible alternative for rural electrification.
- The levelised cost of SSHP projects for low-energy generation is high compared to the levelised cost of grid-connected electricity supply. However, consideration of the infrastructure costs associated with connecting remote communities to the local or national electricity grid renders SSHP for rural electrification feasible.
- Standard containerised turbine room units, similar to the design of the Kwa-Madiba SSHP plant, should be developed for certain configurations of SSHPs and rolled out for rural electrification in South Africa.
- The Department of Water and Sanitation has been approached to review and amend the current applicable General Authorisation, GA1199, to include the construction of small-scale hydropower projects towards non-grid electrification in the rural areas of South Africa.

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Small-scale hydropower is a feasible alternative for rural electrification. Although the accessibility of potential SSHP sites within the study focus area was a challenge, the introduction of electricity to these 39 households will impact positively on the community.