# The potential of small hydro power plants in southern Africa

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**It is estimated that only 24% of the hydro potential in Africa is developed compared to 86,8% in Europe. Most attention in Africa is focused on the various larger projects such as Inga. These will take time to develop, but in the meantime there are a number of smaller hydro plants in progress in Southern Africa and the potential for exploitation of small hydro is being realised as a source of reliable renewable energy for Africa.**

The worry is that, for several decades, governments have focussed on big schemes that have often proved unworkable at the time, the Inga project being a classic example, and more solutions are needed based on localised generation using potential hydro resources [1]. This is the area where medium to small hydro power plants come into their own, especially when associated with electrification programs.

### Small hydropower plants

South Africa de-facto defines small hydropower as below 10 MW because that is the upper limit of hydropower plants in the current bidding process. Other countries in southern Africa do not have their own definition of small hydropower [2].

### Regional overview

Four countries in the southern African region have adopted small hydropower. Lesotho will very soon be able to support projects including small hydropower with its national rural electrification fund. South Africa has an integrated resource plan which includes small hydropower [2]. Swaziland has relatively low small hydropower potential compared to other countries in the region, although several small hydropower plants are operational and there isinterest in refurbishing old defunct plants. The installed small hydropower capacity in the Southern African region is 43,12 MW, with a small hydropower potential of 383,5 MW (Table 2). South Africa dominates the region in terms of both installed small hydropower capacity and available potential. Its potential includes the novel development of harnessing hydropower using existing infrastructure such as water distribution channels [3].

| Country | Potential (MW) | Installed capacity (MW) |
|---|---|---|
| Lesotho | 20,0 | 3,82 |
| Namibia | 108,5 | 0,50 |
| South Africa | 247,0 | 38,0 |
| Swaziland | 8,0 | 0,80 |
| **Total** | **383,5** | **43,12** |

*Table 1 : Small hydropower in Southern Africa [2].*

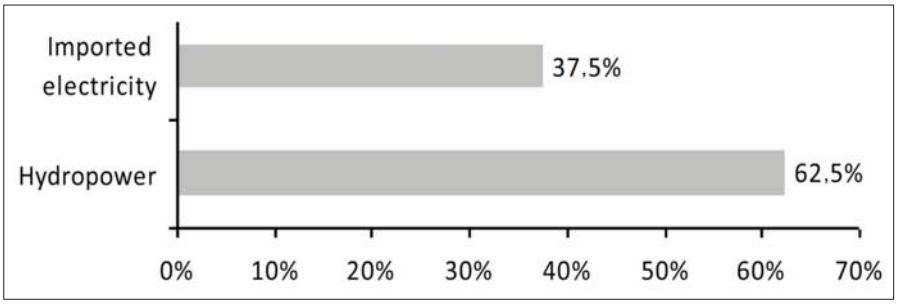


*Fig. 1: Electricity generation in Lesotho [3].*

### Country overview: Lesotho

The electricity sector is relatively small with an installed capacity of only 76 MW, mainly from the Muela hydropower plant linked to and managed by the Lesotho Highlands Development Authority water scheme to provide water to South Africa [3].

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

It is estimated that the large-scale hydropower generation potential for Lesotho is 450 MW. A total potential capacity of 20 MW has been identified at 22 sites (Fig. 2). Nine potential sites in the range of 100 to 1000 kW have been identified and feasibility studies have been completed on three preferred sites: Tlokoeng, Motete and Qacha's Nek.

*Examples of small hydro projects*

Commissioned in the early 1990s, the Tsoelike small hydropower plant is a 400 kW run-of-river installation constructed to serve the town of Qacha's Nek. The plant consists of the two Francis hydropower turbines supplemented by a 200 kVA diesel genset, and another 320 kVA genset at the town of Qacha's Nek. Previously an isolated system, Qacha's Nek was connected to the South African grid in 1997, enabling the hydropower plant to be decommissioned as it was developing serious technical and siltation problems.

Tlokoeng is a 670 kW hydropower station commissioned in 1990 to serve the town of Mokhotlong. The station has two Francis turbines of 460 kW and 210 kW capacity, augmented by two diesel gensets as back up (200 kVA at the power station and 500 kVA at Mokhotlong). During its operation, the plant met an average of 27% of Mokhotlong's electricity demand. The station was decommissioned in 2002 when the 33 kV transmission line from the Letseng diamond mine reached the town of Mokhotlong. Difficult access and limited availability of spare parts for the equipment have inhibited refurbishment of the site.

The Katse Dam contains a 570 kW mini hydropower plant consisting of a horizontal Francis turbine and an 800 kVA synchronous generator. Since its commissioning in August 2000, the plant has been running in an isolated mode from the grid. The intention is to link the plant to the grid and have it operating continuously at an average 500 kW power output.

The Mantsony'ane hydropower plant (2 MW) was commissioned in February 1989. The power station is located on the Mantsony'ane River and feeds the grid through Mantsony'ane substation on the 33 kV Mazenod-Taba Tseka line. The station can operate on an isolated network when required, but the main operational strategy has been to meet daily peak. The station is equipped with two Francis turbines of 1500 kW and 500 kW, together with 1900 kVA and a 650 kVA generators. The station features a storage dam on the river and an unlined 655 m long tunnel from the intake to the rock cavern power house. The design head is 35,5 m.

The power station was flooded at the beginning of November 2006 and has

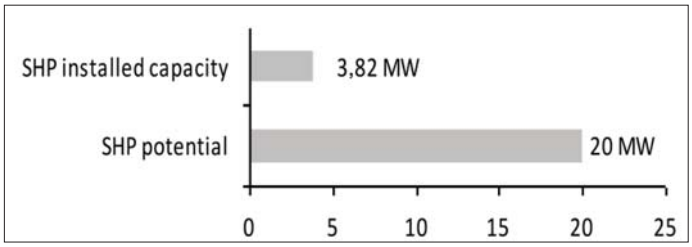


Fig. 2: Small hydropower capacities in Lesotho [4].

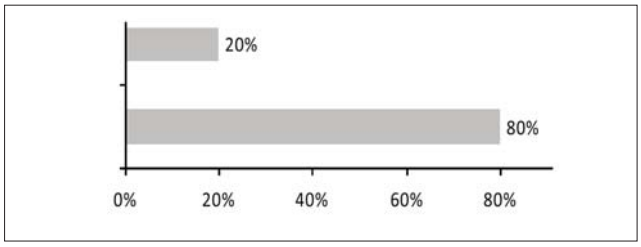


Fig. 5: Electricity generation in Swaziland [4].

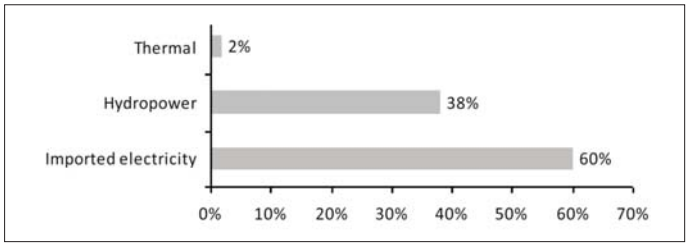


Fig. 3: Electricity generation in Namibia [6].

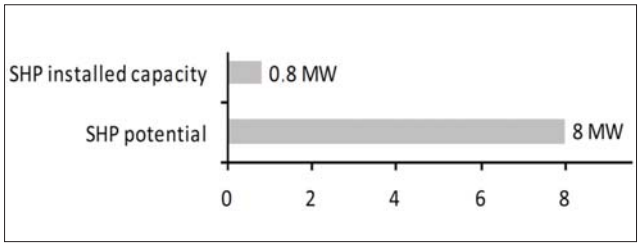


Fig.6: Small hydropower capacities in Swaziland [9].

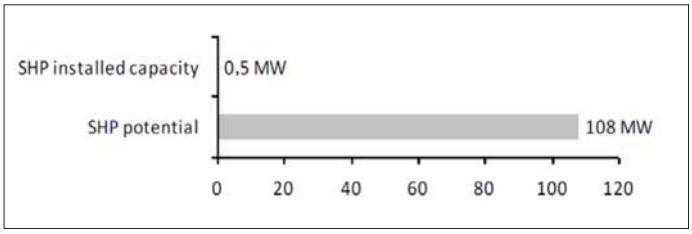


Fig. 4: Small hydropower capacities in Namibia.

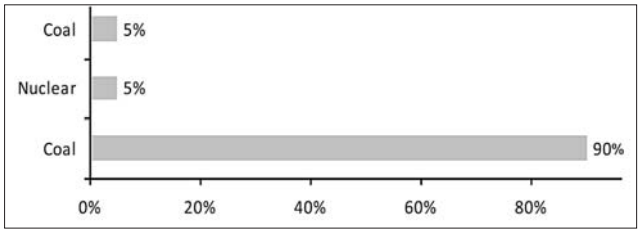


Fig. 7: Electricity generation in South Africa [10].

been out of operation since then. In 2011, the Lesotho Electricity Company was in the process of rehabilitating the power station as part of the African Development Bank's Lesotho Electricity Supply Project. A tender process for the station was started in the second half of 2011.

The Semonkong project currently has an installed capacity of 180 kW of hydropower, supplemented by a 120 kW diesel generator. The plant supplies an isolated community of approximately 25 customers, with the potential of adding a further 50 customers in the future. It contains space for two 190 kW hydropower generation units, and one stand-by peak load 120 kW diesel unit.

*Barriers to small hydropower development*

In order to boost small hydropower electricity production, viable business models for the development of small hydropower in Lesotho need to be found. Barriers to small hydropower development are the difficulties to access some sites and the lack of availability of spare parts in the local market.

### Country overview: Namibia

The vast majority of electricity in Namibia has always been produced by hydropower [5].

The total installed electricity generation capacity in Namibia is 393 MW. With the recent expansion in June 2012, Namibia's largest hydro plant was pushed up to 330 MW. Even with other sources in the country, the total generation still falls short of Namibia's 550 MW demand.

The largest hydropower station, Ruacana, increased its capacity to 330 MW in 2012. The down stream area of Ruacana has as much as 2000 MW of hydropower potential according to the Ministry of Mines and Energy. The country is considering a 500 MW hydropower project that would be located at Epupa Falls.

The country has a hydropower masterplan with a study performed on all perennial rivers, none of which arise from within its borders. The aim of the study was to identify and estimate the cost and production of all potential sites in the lower Kunene, Kavango and lower Orange Rivers. None of the identified sites have a capacity of less than 10 MW, thus none falls into the generally accepted small hydropower definition.

Currently no official small hydropower definition exists in Namibia. It has only an installed capacity of 0,5 MW small hydropower, with a potential of 108 MW (Fig. 5). The national investment brief mentions that there are hundreds of small farm dams scattered around the ephemeral river basins, where small hydropower potential could be developed.

*Barriers to small hydropower development*

The scarcity of water and dependency on neighbours for water supply does little to encourage foreign direct investment due to the huge effect of precipitation on the potential for financial return from small hydropower projects. The continuation of internal land use conflicts with indigenous people who were concerned about the hydropower industry and its impact on their way of life did little to promote the technology.

### Country overview Swaziland

Power in Swaziland is supplied and distributed by the Swaziland Electricity Company (SEC), which operates four grid connected hydropower plants: Edwaleni (15 MW), Ezulwini (20 MW), Maguduza (5,6 MW) and Maguga (19,2 MW) [8]. In December 2010, the SEC decommissioned the small-scale 500 kW Mbabane station, built in 1954, due to unprofitability. Approximately 80 % of Swaziland's electricity is imported from South Africa through the SAPP. The remaining 20% of the electricity requirement is generated by hydropower (Fig. 6).

*Small hydropower sector overview and potential*

Currently, no official small hydropower definition exists in Swaziland. The first electric lighting system in Swaziland was installed at Mlilwane with a 42 kW small hydropower turbine operated by James Weighton Reilly. Since then several public and private hydropower plants have been installed in the country, as well as hydraulic ram pumps to provide water for steam locomotives at the Ngwenya mine.

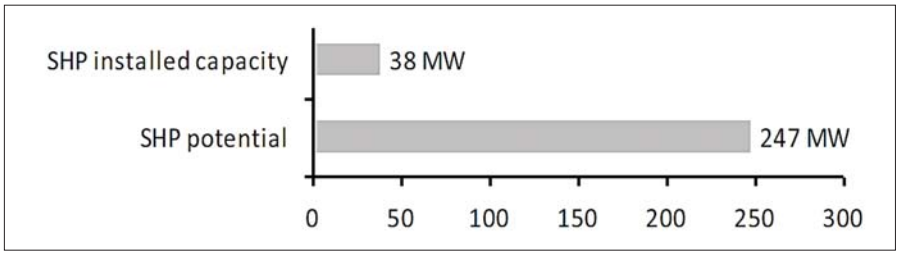


*Fig. 8: Small hydropower capacities in South Africa [11].*

Several studies have been conducted to estimate the hydropower potential of Swaziland. In 1970, the UNDP financed a study which identified 21 possible sites for hydropower schemes. Based on existing information, the Environmental Centre for Swaziland comes to a gross theoretical potential of 440 MW and a technically feasible potential of 110 MW, of which 61 MW are economically viable. The latest full study on hydropower potential in Swaziland showed that there are a number of potential micro (<0,1 MW), mini (0,1 to 2,0 MW) and small (2 to10 MW) hydropower generating sites along the rivers in the country.

*Examples of small hydropower projects*

The 800 kW small hydropower plant of the Swaziland Plantations company was initially commissioned in 1952 and was later built to satisfy power needs of the town of Piggs Peak. The water is taken from the Mkomazana River and stored in a 35 m high dam, before being fed to the power plant through a 1,75 m diameter, 300 m long tunnel.. During summer, when there is an abundance of water, the plant can provide up to 90% of the company's power needs.

Current operations are largely dependent on water availability in winter and dry season production being about a quarter of summer's production. Increasing electricity prices and reduced reliability of the national grid have resulted in increased interest in rehabilitating old hydropower plants. Although no good overview exists on possible sites for refurbishment, it can be expected that a number of sites will be economically feasible to rehabilitate. This will also revive interest by potential investors.

### Country overview: South Africa

Currently no official small hydropower definition exists in South Africa, although the upper limit of 10 MW used in the current renewable energy bidding process de-facto limits small hydropower to 10 MW. 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 such as Cape Town and Pretoria was based on small hydropower, while other smaller towns started local distribution of electricity through isolated grids powered by small hydropower stations.

With the expansion of the national electricity grid, many such systems were decommissioned. A typical example is the Sabie gorge hydropower station, with three 450 kW turbines, commissioned in 1928 to serve the town of Sabie in Mpumalanga and later closed in 1964, after the area was connected to the national grid.

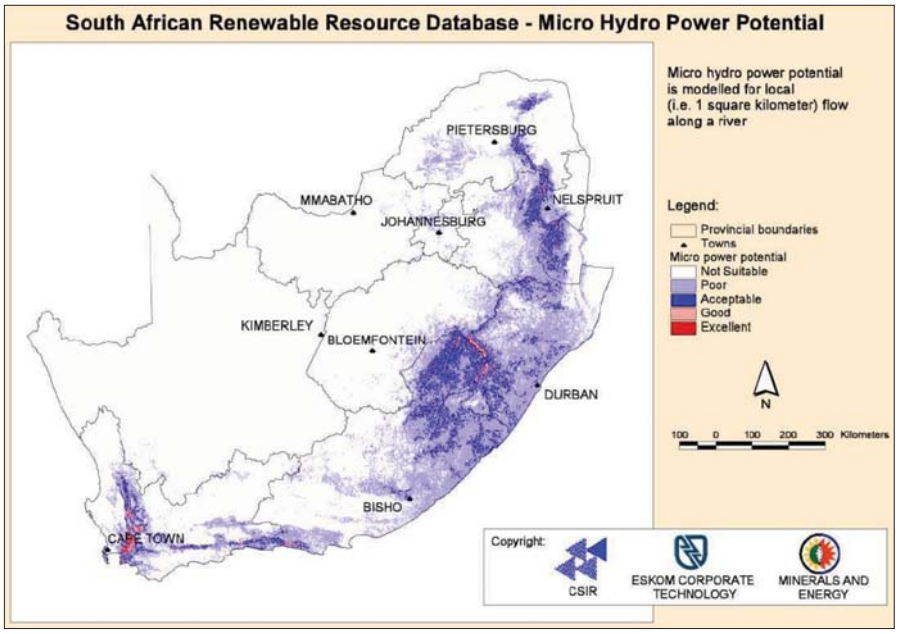


*Fig. 9: Micro-hydropower potential in South Africa [12].*

After nearly 30 years of neglecting the hydropower potential of the country, the first new small hydropower station was commissioned in November 2009 at the Sol Plaatje Municipality and a few other stations are currently in different stages of development.

The South African renewable energy database [8], investigated the available renewable energy resources in the country, including the potential for hydropower. The sources available for the Eastern Cape region was detailed as part of a three-year investigative project titled "Renewable energy sources for rural electrification in South Africa".

Installed hydropower capacity under 10 MW has the potential to be further developed in the rural areas of the Eastern Cape, Free State, KwaZulu Natal and Mpumalanga. A later publication by Barta (2011) [10] includes new insights regarding the potential of small hydropower in South Africa by including the hydropower potential of water transfer systems and gravity-fed water systems, and mentions a total potential of 247 MW of which 38 MW has been developed.

At the moment Eskom is operating two small hydropower stations: First Falls (6 MW) and Ncora (1,6 MW). Municipalities operate another three grid connected small hydropower stations, while companies in the private sector run another two, both grid-connected. There is a substantial number of micro hydropower systems that are in operation, mainly in the KwaZulu Natal and Eastern Cape region, supplying primarily individual farmers. There are a few small-scale hydropower installations currently not in operation, which could be refurbished to working order, such as the ones at Belvedere (2,2 MW), and Hartbeespoort (37 kW) among others.

The South African economy is heavily reliant on water transfer systems and several water distribution companies are currently looking into the possibility of using in-flow hydropower turbines for electricity generation. As part of the research project by the University of Pretoria, a 16 kW pilot system has been installed at the Pierre van Ryneveld reservoir in Pretoria, with preparations ongoing for more systems nationwide. Bloemfontein water board, Bloemwater, is also collaborating in this research project and has taken steps to convert to a sustainable energy source as the main supply of energy for operating their head office in Pellisier.

The Caledon-Bloemfontein potable water supply system supplies the majority of the water demand in Bloemfontein. The water is supplied to the Brandkop reservoir, where Bloemwater's head office is located. Excess energy from the Brandkop reservoir is dissipated through pressure control valves before being discharged into the reservoir. For the Bloemwater project, a 96 kW crossflow turbine and synchronous

generator from Italian renewable-energy company Irem is currently being installed.

*Examples of small hydro projects*

The First Falls small hydropower station has two 3 MW units, with provision for a future third machine. Water is conveyed to the powerhouse through a 27 m long penstock with a 2,7 m diameter steel pipe. Water for the station is discharged at 6m$^3$/s from Mthatha dam, down the river to First Falls. The Ncora small hydropower station has a single 1,6 MW unit. The water is released from the main Ncora dam via a canal to the holding dam.

On the Dorps river, north of the town of Lydenburg, the Thaba Chweu local municipality owns a small hydropower station called Lydenburg. It has a Gilkes Pelton turbine with a capacity of 2,6 MW. The system is operated under contract by MBB consulting engineers.

In 1926 and 1953, the town of Ceres commissioned its first and second small hydropower schemes, with capacities of 95 kW and 1 MW respectively. Unfortunately, this scheme is no longer operational, although rehabilitation could be considered.

The Friedenheim station consists of two Sulzer Francis turbines of 1 MW each. Water for the station is taken from approximately 5,5 km upstream from the Krokodil river, and is transported to the power house site where a head of 64 m is available. The station has been running since 1987. It sells the bulk of the generated electricity through a power purchase agreement (PPA) to the local Mbombela municipality. It is owned by the members of Friedenheim irrigation board (FIB) and is operated on behalf of the board by MBB consulting engineers. The plant provides power for water pumping to FIB, but 93% of the power generated is sold to the municipality.

Bethlehem Hydro owns two small hydropower stations which are normally referred to as "Bethlehem Hydro". These were the first addition of hydropower generation capacity for the last three decades. This system consists of:

- The 3 MW Sol Plaatje power station near the town of Bethlehem which was commissioned in November 2009 and has a generating head of approximately 11 m and a maximum flow of 30 m$^3$/s. A single 2,1 m diameter Kaplan turbine, attached to a generator, is installed at the power station.
- The 4 MW Merino power station is close to the town of Clarens. The project consists of a diversion weir in the Ash river, a 700 m long canal, and a power station situated in a sandstone bank. The generating head is approximately 14 m and a single Kaplan turbine and a generator are installed in the power station.

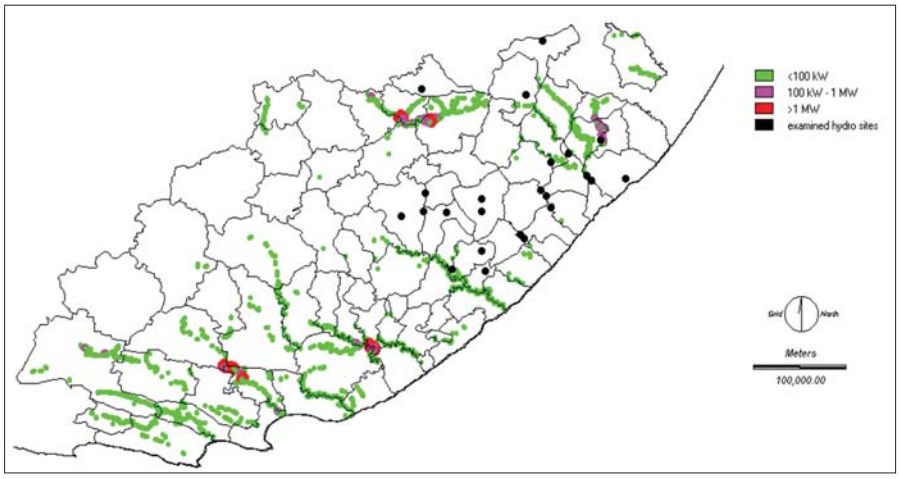


*Fig. 10: Small hydropower potential in the Eastern Cape [13].*

The Bakenkop small hydropower plant was commissioned in 1950 to supply the town of Piet Retief with electricity before it was connected to the national grid. After 60 years of operation, it is still providing power to the town. The installed capacity is 800 kW. The system operates intermittently depending on water availability.

*Small hydropower future*

The future for small hydropower in South Africa will see two main parallel tracks: grid-connected projects which will feed into the national grid and small scale systems for private use. These tracks could be supplemented by a third category of isolated systems for rural electrification purposes. The utilisation of small scale systems for private use is expected to grow based on the foreseen rise in electricity prices, coupled with the reduced reliability of the grid. Off-grid electrification by means of small hydropower could be supported by the renewed focus of the Department of Energy on the off-grid electrification processes.

### Renewable energy policy and small hydropower

In the renewable energy independent power producer procurement programme (REIPPP) a total of 75 MW for has been allocated to small hydropower (up to 10 MW). The second round of REIPPP attracted two hydro developers: the Neusberg plant of Kakamas Hydro Electric Power and the Stortemelk plant of NuPlanet (4,47 MW). Although the Neusberg site has a potential of 12,57 MW, only 10 MW will be developed in order for it to qualify under the REIPPP. No allocation to small hydro was made in the third round. The small projects REIPPP has an allocation of 100 MW to projects in the range 1 to 5 MW, without any technology being specified, and it is expected that a number of small hydro projects will be allocated in this program.

### Barriers to small hydropower development

The main barrier for development of hydropower in South Africa has long been the unclear policy framework from both electricity as well as a water use perspective. With REIPPP, the policy framework is much clearer, although effectively limiting options as development of grid feeding hydro schemes outside the REIPPP has become virtually impossible.

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