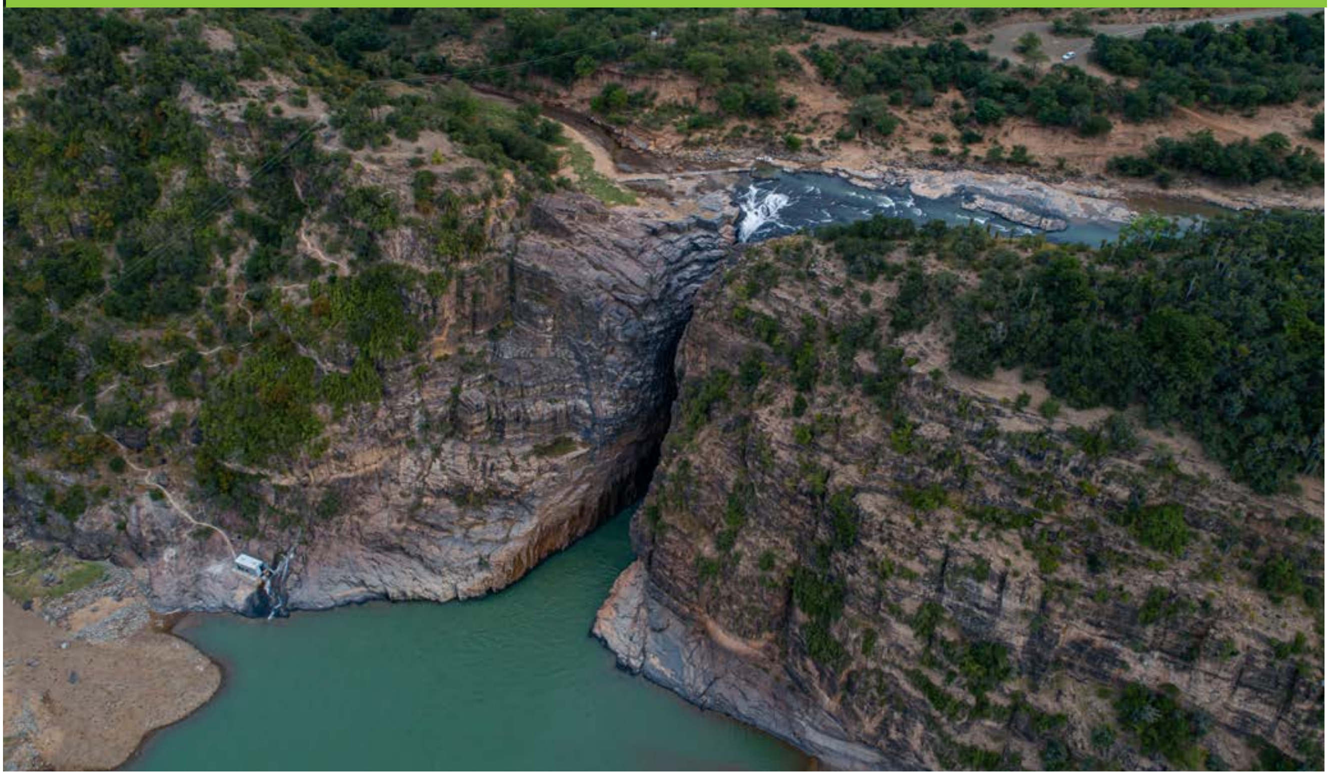
HYDROPOWER

Turning the tide on cleaner energy, one community at a time

Small-scale hydropower offers potential for rural electrification in parts of South Africa, according to the researchers involved in a recently completed pilot project, Jorisna Bonthuys reports.



The Kwa-Madiba micro-hydropower plant is located next to the Thina Falls, along the Titsa River, in the Eastern Cape.

A micro-hydropower plant situated northeast of Mthatha in the Eastern Cape illustrates the potential of renewable energy to help turn the tide for local communities.

This is the view of Marco van Dijk, a lecturer at the University of Pretoria's Department of Civil Engineering. Van Dijk and his team have been exploring this topic over the last few years. Adds Jay Bhagwan, Executive Manager at the Water Research Commission (WRC): "Imagine thousands of such systems serving remote villages, and its potential to create local jobs, industry and enterprises. This could be the green economy which can go far in uplifting local economies and stimulating a renewable industry."

This visionary initiative by the WRC, which is funded by the Department of Science and Innovation, is aimed at changing the rural economy through innovative solutions. The Kwa-Madiba plant that they designed and constructed during this project provides a "useful roadmap" for implementing similar projects elsewhere in the country, Van Dijk says.

The unit, housed in a retrofitted shipping container next to Thina Falls, provides enough electricity for approximately 50 rural households. The electricity is used by people living in the remote village of Kwa-Madiba in the Oliver Tambo District Municipality.

The nuts and bolts

The plant employs the age-old strategy of generating electricity using the potential and kinetic energy of water, Van Dijk explains.

BACK TO TOP

"This run-of-river, modular unit turns the potential energy of water flowing into clean electricity. Its turbine and generator harness energy from water, of which there is plenty all year round."

Thina Falls is situated on the Thina River just before its confluence with the Tsitsa River.

The plant's intake and headrace are at the top of the falls. Its turbine room and tailrace are located at the bottom. A 450 mm-diameter penstock was drilled through the mountain near the site, linking the headrace with the turbine room.

The plant's design allows for rerouting a small quantity of flow for hydropower generation while still maintaining the bulk of the flow over the waterfall. The release from the turbine room is equal to the flow at the intake structure, namely 150 ℓ/s and thus not a consumptive use.

Due to the relatively small extent of the project, the screening process undertaken confirmed that neither a basic assessment nor a full environmental impact assessment was needed before work started.

The water authorisation process was managed in a cost-effective and timely manner, Van Dijk says. This is because a mini-scale hydropower project for non-grid rural electrification is included as an activity in the Department of Water and Sanitation's General Authorisation for water users (in terms of the National Water Act).

The plant was constructed in two phases. Firstly, the intake, headrace, penstock and turbine room foundation were constructed at the site. Secondly, the turbine room was assembled as a containerised unit, prefabricated off-site, transported to the area and placed on the turbine room's foundation.

The turbine room houses the turbine, generator, controls and regulators of the plant. The type of turbine selected offered a smaller power station footprint, hence less civil works. The plant is designed to allow for a complete unstaffed operation. "The system is efficient, dependable and cost-effective," Van Dijk says.

The electricity generated by the plant is used by the remote village of Kwa-Madiba in the Oliver Tambo District Municipality.

Implementing this project was not without its challenges, Van Dijk acknowledges. The biggest challenge was the geology on-site, which affected the construction process. The plant's development process was also "more complex than anticipated", he says. This is due to the nature of the project consisting of civil, mechanical and electrical elements. The inaccessibility of the terrain also caused headaches and required redesigning some plant components.

Small but viable

Small-scale hydropower is a proven, mature technology with a long track record, including in Africa. The gold mines at Pilgrim's Rest in Mpumalanga, for example, were powered by two 6 kW hydro turbines as early as 1892 and was later complemented by a 45-kW turbine in 1894 to power the first electrical railway.

Although not very well documented, small-scale hydropower played an important role in providing energy to urban and rural areas of South Africa. The first provision of electricity to cities like Cape Town and Pretoria was, for instance, based on small-scale hydropower.

Many smaller towns in South Africa also started local distribution of electricity through isolated grids powered by small hydropower stations. However, with the expansion of the national electricity grid and the cheap, coal-generated power supplied through this grid, many of these systems were decommissioned.

"Decentralised electricity generation options such as small-scale hydropower often remain the only viable solution to supply some areas with electricity."

Historically, small-scale hydropower also played an important role in the development of the region. Since the mid-1960s, however, the main emphasis has been on centralised fossil fuel-based electricity generation. Developers and policymakers have only recently begun looking at small-scale hydropower again.

Recently, initiatives have seen the light in many African countries to revive the sector for small-scale hydropower, either through international development agencies or through initiatives led by the private sector. Particularly in Central Africa (Rwanda), East Africa (Kenya, Tanzania and Uganda) and in southern Africa (Malawi, Mozambique and Zimbabwe), new initiatives are focusing on implementing small-scale projects.

Pico- and micro-hydropower installations are often ideal electrification options for isolated communities (that are not grid-connected) in developing countries, Van Dijk says.

The South African classification of hydropower installations refers to plants with a generation capacity of up to 10 MW as 'small' hydropower. Small-scale hydropower schemes are classified into mini-hydropower (<1 MW), micro-hydropower (< 100 kW) and pico-hydropower (< 20 kW).

BACK TO TOP

The plant is located inside a retrofitted shipping container and provides enough electricity for approximately 50 rural households.

Hidden potential explored

Although energy experts say South Africa has moderate hydroelectric potential, small hydropower projects around the country could help provide a sustainable future energy supply according to a WRC study. Van Dijk says: "Decentralised electricity generation options such as small-scale hydropower often remain the only viable solution to supply some areas with electricity."

Such plants can provide renewable options for communities that are currently off the mainstream electricity grid but living near rivers or existing dams that can be retrofitted. "Micro-hydropower can provide one of the most simple and consistent forms of renewable energy in deep rural settings," Van Dijk notes.

In remote locations, stand-alone systems like the Kwa-Madiba plant can be more cost-effective than extending a transmission line to the electricity grid. And, unlike large-scale hydropower plants, these small plants can be built in two to three years from inception, Van Dijk explains. These projects could be stand-alone isolated mini-grids or larger installations linked to the national electricity grid.

As South Africa is an arid country, there is a vast water infrastructure network that has been developed to dam, store, control, measure and convey water to the end users.

According to the researchers, municipalities, water utilities, and government entities (such as the Department of Water and Sanitation) also own and operate water infrastructure which could be retrofitted to generate small-scale hydropower. At many of these locations, there is hidden potential for hydropower, ranging from pico-, micro, or even mini-hydropower schemes, to possibly supply a school or clinic, a cultural village centre or even a whole community.

According to the researchers, the pilot project proves that small hydropower technology can provide grid-quality electricity to rural areas under the current legislative and policy framework. Van Dijk adds: "This kind of small-scale hydropower project also fits into national and regional green economy ambitions."

Bhagwan says this plant offers a case study on how a simple technology, which is smartly modernised in a prefabricated containerised unit, can be quickly expedited to very remote settings where electricity is needed, but access to the national grid may not be a feasible option.

Bhagwan says: "This [type of plant] offers huge potential for several other similar communities in areas such as the Oliver Tambo District Municipality, who are living within the proximity of an adequate water source."

Currently, many barriers are hindering small-scale hydropower development in the region. These include limited access to the appropriate technology as well as limited infrastructure for manufacturing, installation and operation of electromechanical equipment.

The knowledge to develop small hydropower plants is, however, available to implement such projects. Several turbine manufacturers want to enter the South African small-scale hydropower market, Van Dijk says.

Mapping for the future

As part of the Kwa-Madiba project, Van Dijk and his team outlined the necessary steps that must be followed when developing a hydropower plant. They are now also compiling a national hydropower atlas for the country as part of another WRC-funded project.

This atlas, the first of its kind in the country, will help identify potential areas where hydropower projects of different sizes can potentially be implemented. It will also provide information regarding the different technologies available, among others.

The researchers hope their efforts will provide policymakers with a way to address the lack of development in this field and facilitate government plans to exploit hydropower resource opportunities.

So far, work on developing the atlas indicates there are existing and new opportunities for hydropower in the country. There are, for instance, opportunities at existing dams and weirs as

KwaMadiba is a run-of-river, modular unit which turns the potential energy of water flowing into clean electricity.

The release from the turbine room is equal to the flow at the intake structure, namely 150 ℓ/s and thus not a consumptive use.

well as on the bulk supply and distribution pipe system. This infrastructure may be retrofitted with turbines to generate electricity to meet the base or peak electricity demands, Van Dijk points out. The advantage of retrofitted hydropower is that no new infrastructure is required for energy generation, he says.

South Africa has many other potential sites that are suitable for implementing micro hydropower schemes, he says. These include the outlets of existing dams (with South Africa having about 4500 dams across the country) and large-scale water transfer schemes.

Van Dijk says that micro hydropower schemes could provide economical energy output in areas with sufficient water resources. Rural communities from the Eastern Cape, Mpumalanga and KwaZulu-Natal have the most potential to benefit from small-scale hydropower schemes, he says. These provinces have better topography and water resources that can support such hydropower operations.

"Small-scale hydropower is an ideal, renewable energy alternative for the electrification of many isolated communities and to assist in baseload supply," he says.

Efforts are also underway to develop an assessment tool for investors, developers, utilities, and local communities to evaluate hydropower opportunities as part of this research.

The researchers are not propagating building new dams for hydropower, Van Dijk points out. "What we are saying is let's harness (the resources) that we have responsibly, for the benefit of all," he says. "Small-scale hydropower projects like Kwa-Madiba have the potential to be integrated into many of our river systems, wastewater treatment plants, bulk water pipelines and dams."

*The Kwa-Madiba plant has a projected lifespan of approximately 40 years. The local municipality is the owner and will now be responsible for its operation and maintenance. Read more about the project here.

BACK TO TOP