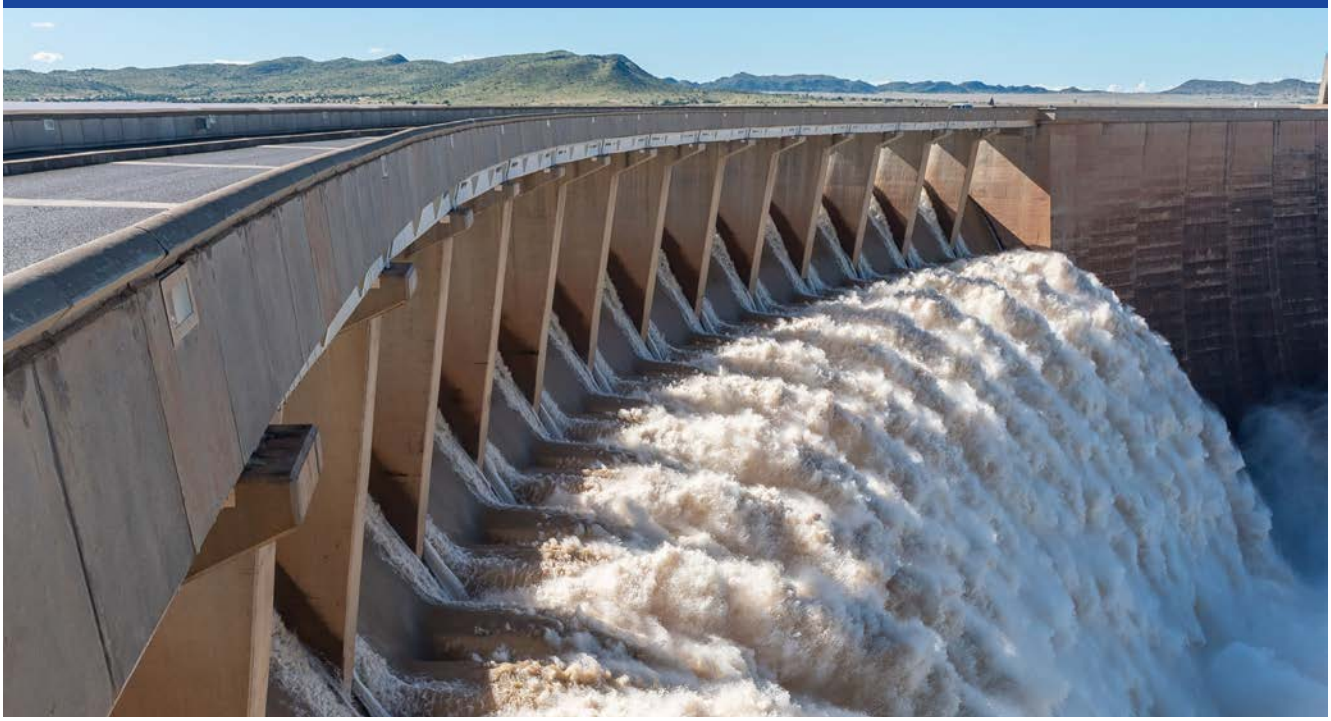
HYDROPOWER

Atlas boost for hydropower

There's great scope for generating electricity at thousands of dams and water infrastructure sites across the country. A new web-based mapping tool helps point the way. Matthew Hattingh reports.



If you're one of the many South Africans who sometimes turns on a tap only to be greeted by groaning noises and hollow coughs, and who much more frequently flicks a light switch, only to confront darkness, there's a chance you may have found yourself asking: Is there some kind of a link between water supply outages and loadshedding? The answer, as it turns out, is: Kinda.

While the two crises have a different genesis, their creation stories have a number of things in common – and we are not necessarily talking about snafus and ***verneukery.*** Something called the water-energy nexus appears to be at play. It's an oft-cited principle that describes the proportional relationship between water supply and energy demand. It tells us that every step of the water and wastewater treatment cycle consumes energy. And almost every power source demands water for its production.

This being the case, "technologies that can couple water and energy supply, especially in areas with high population densities" should be explored. And this is even more true of countries where water is scarce and likely to become more so as climate change hits home. We are quoting from ***The South African Hydropower Atlas***, a recently published Water Research Commission (WRC) publication ***(WRC Report No. TT 916/23)*** which details the development of the eponymous atlas, intended to serve as a database, planning and research tool.

The report's authors and developers of the atlas, civil engineers Marco van Dijk and Anja Bekker and geographers Christel Hansen and Noluthando Mahamba, of the University of Pretoria, noted that atlases had already been compiled for other forms of renewable energy in South Africa. It was time hydropower caught up and promoted its cause.

Meanwhile, a ***Scoping Study to Explore Hydro Potential in the Nearby Vicinity of Baakens River and the Lake (WRC Report No. 3087/1/23)***, also published earlier this year, has put the atlas to the test, using it to identify sites for further study in the Nelson Mandela Bay Municipality and its surrounds. This second report, the work of Van Dijk and Bekker, describes a preliminary feasibility study in the Eastern Cape metro. It explained how this provided a shortlist and also led to the development of a spreadsheet-based assessment tool, which the authors hope will prove useful to other municipalities.

With the shortlist to hand, the researchers spent a week in the field, firming up their preliminary findings. However, at this point they ran into a "major challenge" accessing information. We will return to this later.

Apart from assessing the technical feasibility of the different sites, establishing whether these made rand-and-cents sense was "crucial", so the second report crunched the numbers using familiar financial indicators and techniques. According to the literature, civil works typically account for 40% of the cost of a hydropower project; electromechanical equipment, a similar figure; with the balance going to construction, design fees and management. Yearly operations and maintenance costs range between 0.25% and 4% of the cost of each of a project's main components.

But before we go into more detail, some perspective. Long before rolling blackouts first roiled the country, towards the end of the Mbeki era, and long before the Elektrisiteitsvoorsieningskommissie (Eskom) was established in 1923, electricity was generated by municipalities and private companies. In the early days there was no national grid and hydro often supplied the juice.

The gold mines of Pilgrim's Rest, for example, were powered by two 6 kW hydro-turbines as early as 1892, complemented by a 45 kW turbine in 1894 for the town's first electrical railway. Cape Town and Pretoria once relied on small-scale hydro, while smaller towns started local distribution of electricity through isolated grids powered by hydro stations. "However, with the expansion of the national grid and the cheap, coal-generated power it supplied, large numbers of [hydro] systems were decommissioned."

Back to the present and it seems we may be coming full circle. South Africa's coal-generated power is now neither especially cheap nor particularly plentiful. While hydropower, a proven technology – globally it's the source of 16.5% of electricity and growing – could be on the brink of a local renaissance. Which is not to say it ever left these shores; rather it ceased to be a mainstay of power production.

Figures vary, but South Africa's installed hydropower capacity is reckoned to be nearly 3 500 MW. It's a modest figure relative to the country's 54 177 to 64 500 MW of total generation capacity, most of which is coal-fired. Pumped storage schemes, notably Ingula in KwaZulu-Natal (capacity: 1332 MW), Drakensberg in KwaZulu-Natal and the Free State (1 000 MW), and Palmiet and Steenbras, both in the Western Cape (400 MW and 180 MW), produce the majority of South Africa's hydropower.

These schemes consist of lower and upper dams, with a combined power station-pumping plant between the two. Off peak, when demand for electricity drops, reversible pump-turbines draw electricity from the national grid to pump water from the lower to the upper dam. On peak, water is released, generating electricity.

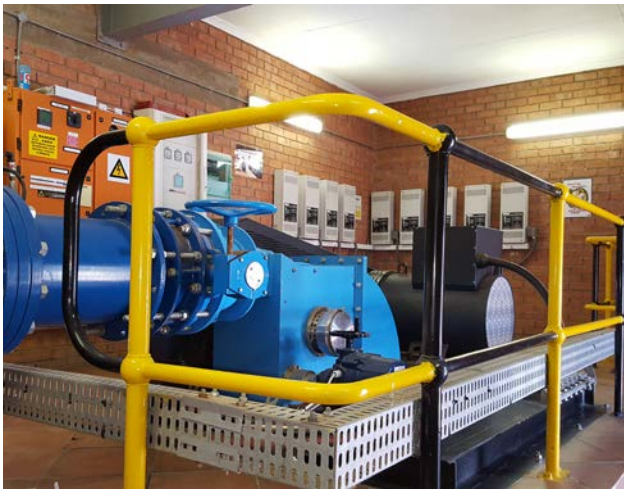
Hydropower has many benefits, as the reports remind us. It's clean, renewable, and comes with low operating and maintenance costs. And particularly in the case of pumped storage schemes, can respond rapidly to changes in demand. But such schemes can mean big capital outlays. Ingula, for example, was completed in 2017 as costs spiralled to R42.58-billion (in today's money). Big dams are even pricier to build and in water-scarce South Africa offer mostly modest power generation capacity. Indeed, only the Gariep and Vanderkloof dams, with 360 MW and 240 MW respectively, come to the national grid party.

Dams also disrupt river-flow, harming natural systems and habitats, including the plants and animals that depend on them. However, many of these concerns fall away in the case of South Africa's numerous storage dams and other gravity-fed water infrastructure. At these sites the environmental damage has already been done and the construction costs long ago sunk.

We are talking here of dams that release water for environmental or irrigation purposes and which "could be retrofitted with turbines to harness the available flow and pressure".

What do we mean by "other infrastructure"? The atlas provides a lengthy list, including, pumped-storage (which we touched on earlier), inter-basin transfer schemes, irrigation, weirs and run-of-river schemes. There are also water and wastewater treatment and distribution systems which are operated by 257 municipalities, several water supply utilities, the Department of Water and Sanitation, mines and even Eskom.

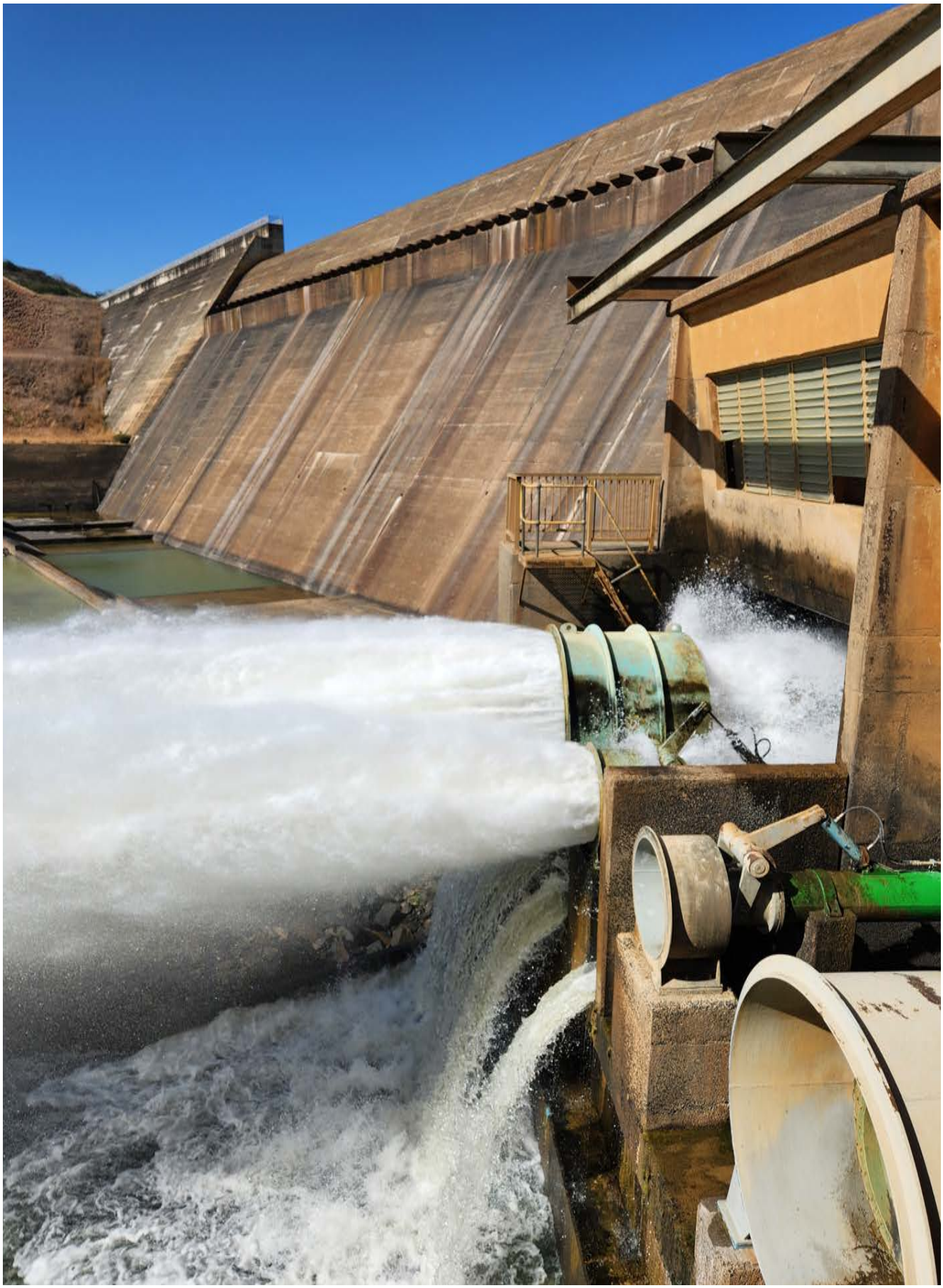
All of this infrastructure, vast networks of pipes, canals and conduits, "could be equipped with turbines or pumps-as-turbines, with the added benefit of supplementing or reducing the need for pressure control valves", the reports observe. The atlas identifies many thousands of megawatts of potential hydropower waiting to be unlocked from a few thousand sites. But in truth, unless done on a large scale, these installations



Marco Van Dijk

The 96 kW hydropower plant at the Vaal Central Water Board's (formerly Bloem Water) Brandkop reservoir in Bloemfontein. The plant was installed in 2015 and powers the utilities' head office.

Marco Van Dijk



Water exiting the sleeve valve at the Spioenkop Dam outlet, near Winterton in KwaZulu-Natal. There is an opportunity to install a hydropower plant at the dam – and at many other such sites across the country.

will make at best a modest contribution to staving off loading-shedding.

Most of the sites fall in the pico, micro and mini ranges – up to 20 kW, up to 100 kW, and up to 1 MW, respectively. Such outputs are dwarfed by Eskom's bomb squad, the newish coal-fired Medupi and Kusile power stations, which have, at least on paper, generating capacities of 4 800 MW and 4 764 MW respectively. Then again, size isn't everything, as fans of rugby's Cheslin Kolbe and Faf de Klerk will tell you. And like the pint-sized Bok backs, small-scale plants are versatile and box above their weight in other ways.

The reports noted rural electrification had been "in the doldrums" because of Eskom's troubles, but small-scale hydro schemes offer a means to jumpstart the rural rollout. It's also a good way to get power to isolated places, dispensing with long, costly transmission lines. What's more, hydropower can help meet the on-site energy needs of waterworks and other "own use" municipal facilities. It can be fed into the grid too (although this comes with plenty of red tape).

Back to the atlas and what went into it. Criteria were developed to narrow down the number of sites for inclusion. For this, the authors drew on Department of Water and Sanitation data, including flow volumes for rivers, canals and conduits. Other data came from: the Surface Water Resources of South Africa studies; the South African National Committee on Large Dams; the department's Green and Blue Drop reports; and municipal water service development plans.

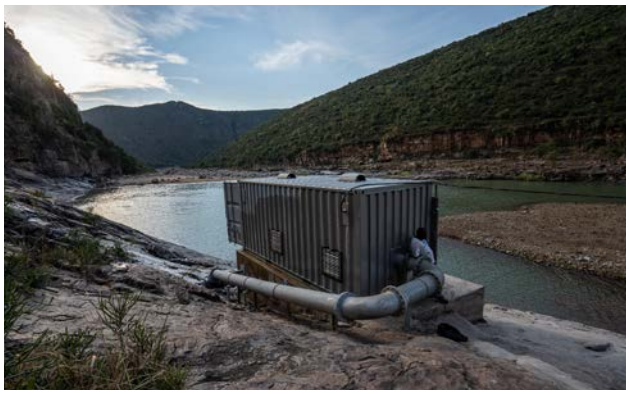
Evaluation frameworks were developed for different forms of hydropower, each with its own parameters, decision flowcharts and tailored formulas for calculating power output. By way of an example, and because the authors believe its inclusion in the atlas represented a first in hydropower research, let's look at the frameworks for wastewater treatment works.

To start with, sufficient data must be available in the Green Drop reports, the annual audit of the country's wastewater plants. If so, the question is: Is the design capacity of the site under consideration indicated? If not, certain assumptions are made. Either way, the plant's likely discharge is calculated. This is then fed into a formula which uses the height difference between a plant and its outlet (or an estimate of this) to calculate the likely power output. Other variables in the equation include the hydraulic efficiency of the intended turbine.

If the calculated output is less than 5 kW the available potential is considered too small and the site excluded from the atlas. So, what does the atlas look like and how do you use it?

It is hosted on the web using ArcGIS Online, proprietary software which the authors felt trumped the open-source alternative in providing a secure and reliable platform. A graphical user interface, with icons, buttons and menus lets users visualise data, zoom in and out or pan across maps or navigate to a particular place or set of coordinates. Multiple users can simultaneously create and share maps, scenes and layers, and add to, analyse and extract data. They can also bookmark, print and share maps.

Layers can be turned on and off, letting users view different combinations of elements in any part of the country. For example, users can view existing hydro schemes (colour-coded



WRC archives

The Kwamadiba micro-hydropower plant, situated northeast of Mthatha in the Eastern Cape, is an example of small-scale hydropower providing much needed electricity to rural communities.

according to capacity), as well as rivers, weirs, treatment works, road networks, municipal and provincial boundaries, and more.

Time to put things to the test. Van Dijk told the ***Water Wheel*** his team was invited to Gqeberha (previously Port Elizabeth) by the Mandela Bay Development Agency, which felt the Baakens River might have power potential. It was later decided to widen the net and look at water and wastewater treatment plants too. Using the atlas, the researchers identified and shortlisted 12 sites for visiting: Six wastewater and one water treatment works; three weirs; one run-of-river site, on the Swartkops River; and the Groendal Dam (outside the municipality).

The next phase of the project should have involved gathering comprehensive information at the 12 sites, but the project hit headwinds. Van Dijk said they had been unable to access most of the sites. He explained that the team had been keen to verify elevations so power outputs could be more accurately calculated. The silver lining to this was that it spurred the team to develop their spreadsheet-based municipal assessment tool, which helped them to produce summary feasibility reports.

The authors recommended that the municipality develop a hydro plant at the Groendal site as a demonstration exercise and that other feasible sites be developed in the next phase. The authors calculated the cost of the Groendal development as R1.57-million and that it would pay for itself in six-and-a-half years. "Clean, renewable electricity would be generated at less than 70 c/kWh."

Van Dijk acknowledged a lack of support from some municipalities and long delays in getting projects to the tender stage was "super frustrating". But he was buoyed by the Department of Water and Sanitation's commitment to opening its facilities to hydropower proposals and water-use applications.

The technology was proven, he said. "It's just the application in a different way; smaller… It's a game-changer."

To view the South African Hydropower Atlas visit: https://bit.ly/3o5qhl3
To view the report, *The South African Hydropower Atlas* (**WRC Report No. TT 916/23), visit:** https://bit.ly/3PVMVH3
To view the report, S*coping Study to Explore Hydro Potential in the Nearby Vicinity of Baakens River and the Lake* (**WRC Report No. 3087/1/23)**, visit: https://bit.ly/3rVMBA6