Secret of improved energy security may lie in our dams and pipelines

While load shedding threatens to keep South Africans in the dark this winter, an untapped source of electricity lies unutilised in South Africa's dams and rivers. And while hydropower will not end all of Eskom's woes, it could go a long way towards reducing demand on the national grid. Article by Lani van Vuuren.

There is no doubt that, along with water, energy is the lifeblood of worldwide economic and social development. In South Africa, this blood runs mostly black as 90% of the country's electricity is generated from coal.

Rolling power cuts such as those that hit the entire country at the start of 2008, coupled with skyrocketing electricity prices, have made all citizens aware of the fact that demand for electricity is grossly outstripping supply. In addition to the construction of additional coal-fired power plants, alternative, renewable energy, must be considered.

As a result of its semi-arid climate South Africa has a vast network of large dams and water distribution infrastructure. According to the South African National Committee on Large Dams, the total storage capacity of the major reservoirs (totalling 252 large dams) currently amounts to about 33 900 million m^3 – equal to about 70% of the mean annual runoff from the land surface of the country. In addition, some 3 500 dams with a height greater than 5 m have been registered with the Department of Water Affairs (DWA). Excluding pumped storage facilities, only seven of the country's dams are equipped with hydropower generation plants, the largest being the Gariep hydropower plant situated on the Orange River, which has an operational capacity of 360 MW.

A recently published Water Research Commission funded study undertaken by the University of Pretoria (UP), illustrates how this infrastructure can be retrofitted to provide valuable additional electricity – albeit at a small scale (known as low head hydropower). As stated in the final report, unconventional hydropower development can take place in both rural and urban areas of South Africa. The report discusses the low head energy potential of eight areas: dam releases, run-of-river schemes, irrigation canals, weirs, urban areas (pipelines and stormwater systems), industrial outflows, wastewater treatment plants, and oceans and tidal lagoons.

A LITTLE ELECTRICITY CAN GO A LONG WAY

According to main authors Prof Fanie van Vuuren and Marco van Dijk of the UP Department of Civil Engineering, the potential annual energy output from identified available capacity hidden in existing water infrastructure could produce between 35 and 115 GWh. This is potentially significant given that 100 kW is equivalent to the average energy demand of 65 households in South Africa.

Just by retrofitting 62 of DWA's most suitable dams could reduce the department's overall electricity demand on the national grid by between 170 and 360 GWh a year, the report states. By implementing low head hydropower technology at 20 suitable municipal dams municipal electricity demand could be reduced by between 35 and 50 GWh a year.

"This potential is not necessarily substantial with regard to the contribution to the Eskom national grid, but is significant with regard to the potential reduction in electricity demand on the overloaded national power generation capacity," the authors say. "In addition to helping Eskom to deliver coal-fired electricity to other needy users, implementing determined low-head hydropower will create various job opportunities in the manufacturing and operation/maintenance economic sectors."

For water supply utilities (including water user associations and municipalities) introducing enhanced in-house energy generation will alleviate, to some extent, dependency on the already stressed national grid and keep their energy costs down.

Ironically, small hydropower has played a historically significant role in the implementation of electricity projects in South Africa, with the first project being a 300 kW station on Table Mountain in 1895. Early large dams, such as Hartbeespoort Dam, in North West province, and Clanwilliam Dam, in the Western Cape, were originally constructed with hydropower stations.

Unfortunately, many of these small-scale hydropower stations have fallen into disrepair. In many cases they were replaced by Eskom's (at the time) cheap and reliable electricity. In other cases, it was because of poor maintenance and general neglect. The time has now come to revive this technology. Van Vuuren and Van Dijk believe South Africa's possesses the technological know-how to do so.

As part of the WRC project, four irrigation schemes were investigated in detail to determine the potential

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Estimates of the country-wide potential for low-head hydropower development

Low head hydropower location	Estimated potential (MW)	In existing infrastructure (MW)	Estimated potential "greenfield" conditions (MW)
Small (low-head) dams	5.70	5.70	As per new dams installed
Run-of-river schemes	39.50	17.00	22.50+
Measuring weirs	0.30	0.30	As per new weirs installed
Irrigation schemes	5.50	5.50	No new developments envisaged
Wastewater Treatment Works (WWTW)	2.50	2.50	As per new works and rehab/upgrades
Urban storm water systems	0.10	0.10	Insignificant
Water transfer pipelines and canals	0.65	0.65	As per new transfers and rehab/upgrade
Industrial outfalls	0.25	0.25	As per new industry installed
Subtotal for inland hydropower	54.50	32.00	22.50+
Tidal lagoons and harbours	26.50	As per further research	26.50
Wave energy systems	Unlimited	None	Unlimited

Source: Scoping study: Energy generation using low head hydro technologies

What is low head power generation?

Low head hydropower generation refers to electricity generated from a relatively low pressure head, normally found in rivers or irrigation channels, and is applicable to sites with less than 5 m of head.

for hydropower within existing infrastructure, namely Boegoeberg, Kakamas, Lower Fish and Sundays irrigation schemes. Hydropower potential was identified at all of these schemes, with a scheme such as Boegoeberg having an estimated total of low head hydropower capacity of 623.76 kW, mostly from its main canal and bulk water sluices.

Wastewater treatment works are also viable sources of hydropower due to the high volume of water that generally flows from such facilities. The flow rates at these treatment works are fairly constant so that no dam or reservoir is required. The project found two opportunities for hydropower generation at these plants – before treatment and at the outflow of the plant.

CLEAN, RENEWABLE ENERGY

Low head hydropower offers various benefits. In addition to being a renewable energy source with high reliability, it uses proven technology, has a long life span (50 years or more), can accommodate flexible operation, has high efficiency, and very low operating and maintenance costs. Preliminary feasibility studies indicate short payback periods, especially when retrofitting onto existing water infrastructure. Another advantage is that hydropower schemes often have more than one purpose. Hydropower through water storage, for example, can assist with flood control and supply water for irrigation or consumption.

Why is this potential only being recognised now? Technologies have improved over the last couple

The Hartbeespoort Dam is estimated to have a hydropower potential of about 5.7 MW.

Lani van Vuuren

of decades, which now allows for the development of previously unfeasible sites. According to Prof van Vuuren, this is coupled with the recent emphasis on the renewable energy sector as well as the high electricity price escalations (> 23% for three years and 8% last year). All of these factors are now working towards making low head hydropower more viable.

REGULATORY CHALLENGES

The implementation of this technology will not come without its challenges. Specific authorisations are required before constructing any hydropower plant. Firstly, permission must be obtained from the owner of the water infrastructure, be it DWA or a municipality. Secondly, a water use licence is required. In general, the generation of hydropower does not consume water or create an additional demand, in which case the only applicable costs are the water use charge.

Developers of low head hydropower will also require a generation licence from the National Energy Regulator of South Africa (NERSA). Lastly, hydropower can be generated for a number of reasons and sold to an array of different people, including private enterprises, local municipalities and Eskom. Whatever the case, a power-purchase agreement must be signed with the authority or purchaser of the electricity under the supervision of NERSA (unless produced for own use).

NEUSBERG WEIR HYDROPOWER DEVELOPMENT

Small-scale hydropower development is becoming a reality in South Africa, with the Neusberg Hydroelectric Power Project project, on the Orange River, already underway. The project, where construction started in 2013, is a run-of-river hydropower station that uses the natural flow and drop in elevation of the Orange River to produce electricity.

The project is being undertaken by Kakamas Hydro Electric Power, a consortium comprised of HydroSA, Hydro Tasmania, Old Mutual and the Kakamas Community Trust. Located 12 km east of Kakamas the project will generate 71.9 GWh of energy per year – enough to provide power to about 5 000 households.

According to the project website, infrastructure includes an offtake weir and 130 m of inlet canal, an inlet structure fitted with a radial gate, 1 400 m of open canal waterway, a reinforced concrete forebay sutrcture, a partially buried powerhouse, a 300 m-long tailrace canal, and a 21 km-long transmission line to the Eskom distribution network.

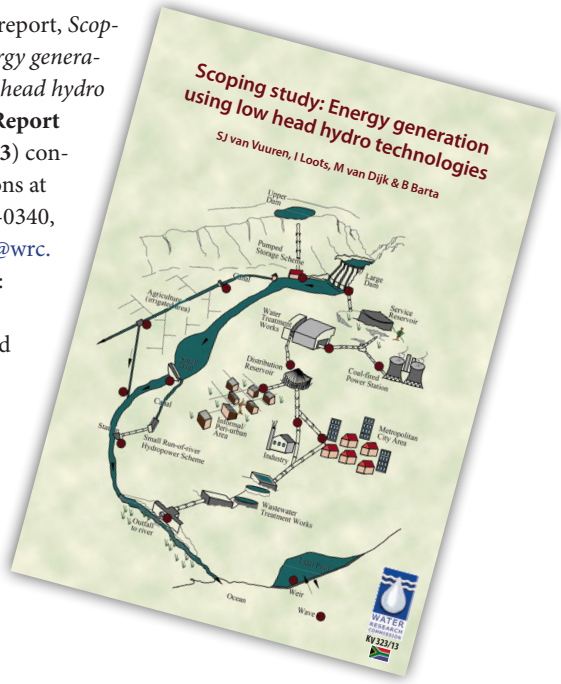
Interestingly, both an environmental authorisation and a water use licence were required for the scheme as it has a significant construction component and water is abstracted from a natural resource.

In order for small-scale hydropower technology to move forward, it would be beneficial if Eskom and local municipalities could join forces and provide easier access to their electricity grids, notes Prof Van Vuuren. "This would allow linking of this 'base load renewable energy' to assist in a small way to the total energy demand of the country."

Although the relative contribution to the grid from low head generation might be seen as minimal, it is believed that the attitude of consumers will be positively influenced by experiencing sensitivity to small-scale development and its potential to have a multiplying effect in the economy.

The available technologies have been introduced to various stakeholders. Also in the pipeline is the establishment of the Hydropower Association of Southern Africa, which will further enhance the status, uptake and implementation of the renewable technology.

- To obtain the report, *Scoping study: Energy generation using low head hydro technologies* (**Report No. KV 323/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy. ❑



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