WATER AND POWER GENERATION

Despite ageing infrastructure Eskom still on par with world water efficiency levels

What to make of Eskom? The loadshedding it unleashed 13 years ago continues to grip the country's economy. We've grown resigned to our lights going out, even as revelations about the public power utility emerging at the Zondo Commission into state capture and corruption still possess the power to shock us, writes Matthew Hattingh.

Spectacular debt saddles Eskom, yet it needs to find ways to spend even more while somehow reining in tariff hikes. It's enough to blow the biggest of fuses, but at the same time, there's a different Eskom to consider, one that's a world leader in certain water-saving energy generation technologies.

The utility is the largest producer of electricity on the African continent. While producing 95% of South Africa's electricity and, in the face of a difficult set of circumstances, it manages to stay in line with world power sector averages for water consumption. It also holds itself to some exacting, even laudable, standards for water use.

In the mid-1990s the power giant adopted a philosophy of zero liquid-effluent discharge. Under normal circumstances operations at its power stations do not lead to spillages into the environment.

Eskom has put in place systems to recover, recycle and reuse water in a number of often complex ways, particularly for cooling at its 13 completed coal-fired stations. And the utility ticks boxes, or was aiming to, for more than a dozen best-practice indicators.

These and a host of other water-related insights are the stuff

of one of the latest reports published by the Water Research Commission (WRC) titled ***Natsurv 16: Water and Wastewater Management in the Power Generating Industry*** (**Report No. TT 853/21**). The report is the second edition of this survey of water use in South Africa's power generating sector. It continues the work of the previous edition – published in 2005 – which looked at national electricity production and capacity as well as intake and management of water, including quality and treatment. That was a couple of years before rolling blackouts became a way of life in South Africa and in other ways too, much water has flown under the proverbial bridge.

Climate change now occupies a more prominent place on the world's agenda so its implications for electricity generation, including possible shifts in rainfall patterns, received attention in ***Natsurv 16***. Similarly, while the previous survey did not consider renewables, the latest one does in some detail. And it may come as a surprise to many to learn that South Africa leads the world in spending on renewable energy as a percentage of its gross domestic product (1.4% in 2015).

From a water-use perspective, some renewables, including wind and solar photovoltaic generated electricity, have much to recommend them. Once installed they need little water to operate beyond an occasional wash of turbine blades or panels. But in at least one fundamental way South Africa's power generating landscape has not changed significantly since the last survey. The report's authors, Gina Pocock and Hannes Joubert, observed that the central role of coal in electricity generation would continue until locally available resources start to diminish. (And this seems unlikely any time soon given that the country's coal reserves rank among the world's top eight.) "However, technologies that utilise water efficiently will have to play a more dominant role in order to preserve national water security," they said.

So how much power and water are we talking about? At the time of the previous Natsurv, South Africa produced 192 000 gigawatt hours (abbreviated as GWh) of electricity. A single gigawatt hour is one billion watts delivered over an hour. Put differently, it's the power you would get from roughly 1.3 million horses working together, based on a horsepower to watts conversion where 746 watts equals 1 horsepower.

By 2018/19 many more horses had been roped in. Power production grew 18% to 234,407GWh. Over the same period, water use rose too, from 245,000 to 292,344 megalitres (abbreviated as ML) a year.

Is that a lot of water? It's a matter of perspective. The 2018/19 figure amounts to a little more than, for example, the capacity of Pietermaritzburg's Albert Falls Dam – the country's 16th largest impoundment by volume. But it's more useful to consider water used for power production as a percentage of the country's total water use or to look at in terms of efficiency. In other words, how many litres of water does it take to produce a given amount of electricity, typically expressed as litres per kilowatt-hour (abbreviated as ℓ/kWh).

This is precisely what Pocock, a specialist consultant at Waterlab, an analytical chemistry and multidisciplinary water services company, and Joubert, of water treatment innovation company VitaOne8, have done.

The authors sent questionnaires to Eskom and renewable energy producers to gauge water quality, specific uses

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Kendal power station, outside Witbank in Mpumalanga is one of the largest dry cooled power stations in the world. The water consumption of South Africa's dry cooled power plants is among the best in the world.

The cooling towers of the Grootvlei power station. While the old, recommissioned Eskom power stations are helping to meet the demand for electricity they are not as water efficient.

and consumption versus power production at different plants employing different technologies. They completed a literature review of the industry in South Africa and boned up on international practice. This gave them benchmarks for comparisons and supported a broader analysis.

The generation of power represents about 15% of the country's gross domestic product and Eskom is classified as a strategic water user. It's a level of importance reflected in the many schemes developed over the years to transfer water among catchment areas to supply power plants.

Power generation accounts for a modest 2% of South Africa's freshwater use – irrigation mops up the lion's share (60%), followed by municipal-urban use (24%). But water is scarce, partly due to a growing population and economy. And the authors reminded us of the looming spectre of climate change and the consequences this may have in the future.

"Water supply to South Africa's coal-fired stations is not considered to be at risk over the short to medium term due to healthy dam levels," the report said. "However, the Department of Water and Sanitation is experiencing severe financial constraints, which may affect its ability to manage existing and implement new bulk water infrastructure to ensure water security to Eskom."

So there's no time for complacency and Eskom is under the cosh to curb its consumption. How then, were the utility's water-saving efforts working out and what about those efficiency figures?

On average in South Africa, production of 1kWh of electricity consumed about 1.4 litres of water across all technologies. This puts the country in line with the world average of 1.2-1.5 ℓ/kWh. But according to Natsurv 16, it also represented an increase in water use of 0.27 ℓ/kWh (9.2%) in the 16 years since the previous survey.

To understand why things have slipped, it's helpful to consider how Eskom generates electricity. Leaving aside renewables, nuclear energy and a few other sources, it's chiefly done by burning coal to heat water to make steam. This in turn, turns turbines which drive giant electrical generators.

In 2018/19 Eskom produced 200 210 GWh of coal-fuelled thermoelectric power. The figure represented 83% of the total electricity the utility made available for distribution or own use. Coal, clearly, is king. But a bit like those ***Animal Farm*** pigs, some coal-fired stations are more equal than others.

The water used to make steam is only part of a bigger power station water-use equation. By far the largest use of water is for cooling turbine exhaust steam. For the purposes of South Africa's coal-fired stations, cooling comes in three varieties:

- Recirculated wet, which uses relatively large quantities of water;
- Dry cooled, which uses much less than the wet variety; and
- Hybrids, which combine elements of both and are somewhere in the middle so far as usage.

Each variety (and a bunch of sub-varieties) has its pros and cons and the report spells these out. It also looks at the cooling systems currently in place at each of Eskom's power stations and explains why the composition of its fleet (an energy geekspeak collective noun) has changed over the years and its effect on water use.

Eight of Eskom's 13 coal power stations use wet recirculation systems. In a nutshell, it circulates cold water through what is known as a condenser, to cool the exhaust steam exiting the turbine. This is necessary to squeeze maximum efficiency out of the turbine itself and so that turbine steam can be cooled back into water and reused.

It's a heat exchange process and the cooling water gets hot in the process and must be cooled for reuse too. To do this, it is pumped to a cooling device, such as a pond or a tower (picture those vast, wide-based-pinched-waisted concrete structures we associate with power stations). In an airstream within the tower, a portion of the water is evaporated, promoting cooling.

Evaporation and other factors lead to a loss of water from the system. "Water demands of between 2.04 and 2.38 from the predominantly wet-cooled closed loop thermal power plant fleet are somewhat above the typical mean intensity of 1.7 ℓ/kWh [for comparable plants]," said the report, citing the National Renewable Energy Laboratory, a US federal government-funded research facility.

In the case of dry cooling, air is used in the place of water to bring down the temperature of turbine exhaust steam. Water consumption with this system is between one-tenth and one-twentieth of a wet recirculation system.

According to the report, the water consumption of South Africa's dry cooled power plants is among the best in the world. It

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quoted water-use figures for the country's direct dry stations of 0.12 ℓ/kWh, which were "in line with international estimates of 0.1 ℓ/kWh". Kudos for Eskom.

But as the economists like to remind us: there ain't no such thing as a free lunch. Dry cooling systems are more expensive to build and, crucially, don't work as well as wet cooling systems in hot and dry conditions. Air is less efficient as a coolant than water so massive fans are needed to help things along. This results in a parasitic drain on electricity production and the report puts the loss at 2% a year on average, but up to 25% at the peak of summer – the very time when electricity is needed most.

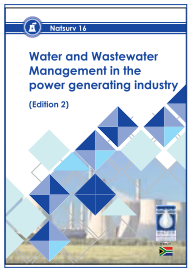
Back to the question: why have overall water-use figures slipped? "This can be attributed to the decreasing thermal efficiency and increasing age profile of the power plants," said the report. In other words, Eskom's power stations, particularly its wet-cooled ones, were getting long in the tooth. The old fellas didn't work as well as they used to and some had developed a bit of a drinking problem.

But Eskom's stations weren't merely old, cranky and thirsty. There weren't enough of them. From 2006 to 2009 (remember, loadshedding began in the later months of 2007) the utility took three retired coal-fired stations out of mothballs to help meet peak-hour demand.

Trouble was, the return-to-service power stations – Grootvlei, Camden and Komati – were not so much old themselves, as positively geriatric. Ground was first broken on Grootvlei in 1969; Camden was built from 1967 to 1969; and work first began on Komati in 1961. Heck, back then Elvis 7-singles were topping the charts; today, the kids are listening to who-knows-what on Spotify. Little wonder then that water consumption for the three was expected to reach 3 ℓ/kWh by 2020. And there's another problem: the three water-intensive power plants are all in severely constrained water management areas, namely Olifants and Inkomati.

Pocock and Joubert argue that from a water perspective they need to be retired while new build power plants are commissioned. Work on two new dry cooled power stations, Medupi and Kusile, began in 2015 and 2017. These are being equipped with the latest in dry cooling and boiler technology and as more generators come on stream at the two and ultimately as the return-to-service stations are decommissioned, net savings of about 35 gigalitres are expected.

However, the authors cautioned that decommissioning and switching to more water-thrifty power generation must be carefully considered. The taps must be tightened, even as the lights are kept on.



Download the report, ***Natsurv 16: Water and Wastewater Management in the Power Generating Industry,***
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