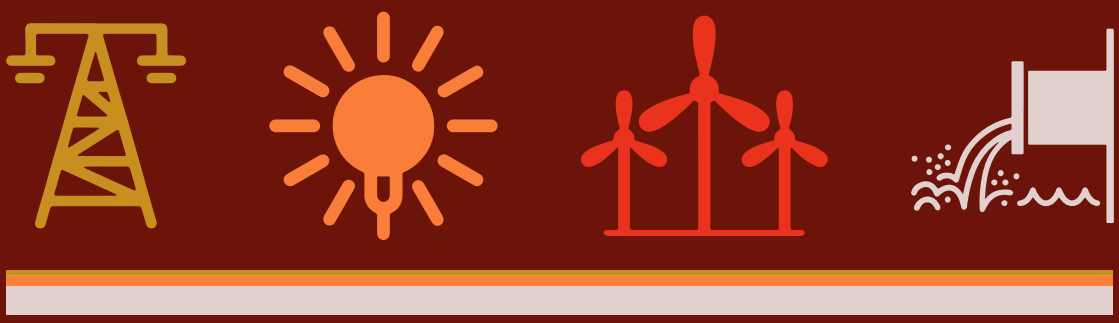
EMG

FACT SHEET SERIES



The Water – Energy Nexus

EMG
Environmental
Monitoring Group

Nexus (noun): a connection or series of connections linking two or more things.

The water-energy nexus poses complex challenges for South Africa. South Africa is water scarce and has been subject to electricity load shedding for the past years. Climate change will exacerbate both water and energy insecurity. The limited fresh water resources are already fully allocated, over-exploited and polluted. The drought crisis of 2015 is evidence of what we can expect in the coming years.

The way we generate energy and provide water, and the way we use these resources for economic development impacts negatively on people and the environment. Poor people are the worst affected by water insecurity, energy insecurity and climate change, and the least likely to experience meaningful benefits from development as we know it. Thus, unsustainability at the heart of the water-energy nexus is a social justice issue.

It takes water to generate energy. It takes energy to provide water.

Water for energy

Mining
Processing of minerals
Contamination (e.g. AMD)
Dust suppression
Steam and cooling processes at power plants

Energy for water

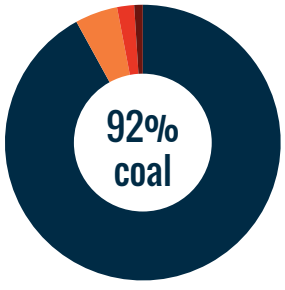
Wastewater management
Heating of water
Treatment
Pumping
Construction of dams

Water for energy production

The National Water Resources Strategy prioritises water for electricity generation as a key strategic use – this means that the energy sector is guaranteed water. The energy sector uses 2% of our national water; however, this does not take into account the water used in mining the raw materials needed to produce energy.

Eskom dominates the South African power sector, and its generation of electricity relies on coal (92%), nuclear (5%), hydropower (2%) and other (1%).

Electricity from coal, nuclear power, hydropower and renewable energy all involve the use and pollution of water.



5% nuclear
2% hydropower
1% other

Energy footprint for different stages of water production

Electricity is required for every stage in the provision and treatment of water.

STORAGE

Dams require a lot of energy in the construction phase, for excavation and the production of concrete. Concrete is energy intensive to make and contributes to climate change through the release of carbon dioxide when limestone is converted to cement.

Dams also release a large amount of methane due to the rotting of plant matter, and can have devastating social impacts due to dislocating communities.

ALTERNATIVE SUPPLY OPTIONS

Alternatives to impounded surface water are the use of treated wastewater, desalination and groundwater.

The use of treated wastewater for non-agricultural irrigation and industrial processes is very energy efficient, because it does not need to be treated to a high quality. The further away and the more sensitive the end user, the higher the energy costs in terms of pumping and additional treatment.

Desalination is extremely energy intensive and expensive. If the water is to be used for drinking water, it is often desalinated twice in order to get rid of the brackish flavour. It will also be more expensive to buy desalinated water, making it out of reach for poorer people. This is therefore a poor choice in the context of energy insecurity and climate change.

Groundwater can be an energy efficient source of water, especially if the water is uncontaminated and therefore does not require much treatment to make it drinkable. However, the ecological impacts of extracting groundwater and aquifer water can be far-reaching and difficult to determine.

DISTRIBUTION

Pumping is needed to collect and distribute water. The amount of energy used to pump is very dependent on the local topography. Ethekwini municipality, uses 5200 kWh of electricity per day for distribution and 5 600 kWh/day for collection of water and wastewater. In Cape Town, water distribution uses much less electricity, because the majority of the city's reservoirs are at an altitude of 100 metres, and so the water travels to consumers under gravity. Some pumping is required for collecting wastewater and getting it to the wastewater treatment plants.

TREATMENT OF 'RAW' WATER

Treating water until it is in a drinkable state depends on the quality of the 'raw' water. Usually, water needs to have the colour removed, organic material and bacteria removed, and the acidity adjusted to a neutral pH so that it does not corrode the pipes. Cape Town's water is treated with lime and ferric chloride to remove the tannins, with CO_2 to neutralise the pH, and with chlorine to disinfect it.

In Durban, Umgeni water uses an ozonation process to get rid of organic matter in the water – this uses a lot of electricity.

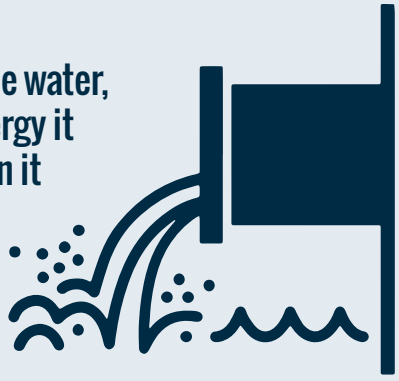
WASTEWATER TREATMENT

This stage uses the most electricity in the whole 'lifecycle' of potable water. Conventional wastewater treatment in South Africa, the activated sludge process, uses large amounts of electricity to power large air blowers that move the sludge around. At the Southern Wastewater Treatment Works in Durban, 9700 kWh/ day are used in activated sludge treatment.

A lot of chemicals and cement structures are used in this method of wastewater treatment, which obviously also takes a large amount of energy to produce. Using renewable energy to power wastewater treatment plants, biogas digesters to convert methane into electrical energy in situ or using alternative methods such as algal ponding systems, would go a long way towards reducing the energy footprint of water.

Another possibility is decreasing the use of wastewater to be treated by introducing dry toilets. These have been met with resistance in many communities where they have been introduced.

The dirtier the water, the more energy it takes to clean it



Water footprint of different sources of energy

In 2011, Eskom used 327 million kilolitres of water in its power plants, to produce 237 430 Gigawatt hours. This means 1.38 litres of water is used to produce each kWh of electricity. However, this number does not include water used in the 'full life cycle' of electricity generation. Here is a look at the bigger picture.

COAL

At coal mines, water is used to extract and wash the coal, for slurry dams and dust suppression. Total water use for coal mining is approximately 400 litres/ton. South Africa's coal mining industry has annual coal production of 255 Mt and water consumption of 102 million kilolitres. Effluent discharged from coal mines is a mixture of hazardous acid generating sulphides (acid mine drainage or AMD) and toxic heavy metals. This can contaminate water downstream for decades, effectively removing that water from the available supply. It takes a lot of energy and chemical inputs to treat it, and mine owners seldom take responsibility for this additional cost.

Coal-fired power stations use water for steam generation and cooling purposes. In 2011 Eskom's coal fired power stations used 327 million m^3, which is roughly the same as the amount that Cape Town uses annually.

All of Eskom's thermal power stations except two currently use wet cooling technology. Dry cooling can reduce a power station's water consumption by up to 95%. All new coal fired power stations in South Africa will use dry cooling technology (a small comfort).

Solid waste from coal-fired power stations, in the form of coal ash, is mostly deposited next to the power stations in ash dumps or dams. This coal ash causes air pollution and contaminates the ground water through slow leakage. Toxic elements that leak into the groundwater in this way include lead, thallium, barium, cadmium, chromium, mercury, nickel, selenium, uranium and thorium.

When you consider that coal also generates 11 billion tons of CO_2 globally per year and therefore is a massive contributor to global climate change, it is clear that we should KEEP THE COAL IN THE HOLE.

NUCLEAR

The uranium mining process produces similar environmental impacts to coal mining, with the added hazard that uranium mine waste is radioactive. The risk of water contamination from heavy metals and radioactive elements after mines close is high.

Nuclear power stations use salt water for cooling purposes. At peak operation, Koeberg uses 80 000 litres of seawater per second, and 1000 litres of fresh water (for steam and other purposes) per day. The fresh water required for nuclear power stations is often obtained from desalination of sea water – this is energy intensive, and impacts on marine life through the disposal of warm toxic brine directly into the sea.

FRACKING

Fracking, or hydraulic fracturing, is not yet underway in South Africa, but our government is very eager for it to go ahead, and has and has lifted the moratorium on exploration. Fracking poses multiple threats to water: it consumes a huge amount of water, it contaminates groundwater, and it carries high risks of leakage and spillage of very toxic 'frack-water'.

In an arid region (particularly the Karoo, where a lot of the current fracking concessions are held), in a water scarce country, in the context of climate change, fracking should be absolutely rejected (for more information see EMG's Fact Sheet 1 on Fracking).

HYDROPOWER

Large dams used to generate hydroelectric power contribute to water consumption mostly through evaporation. This has been calculated to be in the region of 68 litres/ kWh. Their other adverse impacts include massive ecosystem alteration, the displacement of people, and contribution to climate change through the release of methane from rotting plant matter.

South Africa currently gets only about 2% of its electricity from hydro-power schemes. However, in the future renewable energy from solar photovoltaic and wind power plants will need to be stored somehow, and pumped storage schemes using large dams is one likely option. We need to be aware of the environmental and social costs of large dams.

WIND POWER

Wind power plants do not consume water for power production during their operational life-time. However, wind power generators require the mining of rare earth elements (REEs) to be used in their permanent magnets, and this mining has impacts on water.

South Africa's REE mines are located in the dry Northern Cape. As these mines go into operation in the near future, it will be critical to monitor and avoid the pollution of surface and groundwater, as has happened at REE mines in China.

SOLAR THERMAL POWER

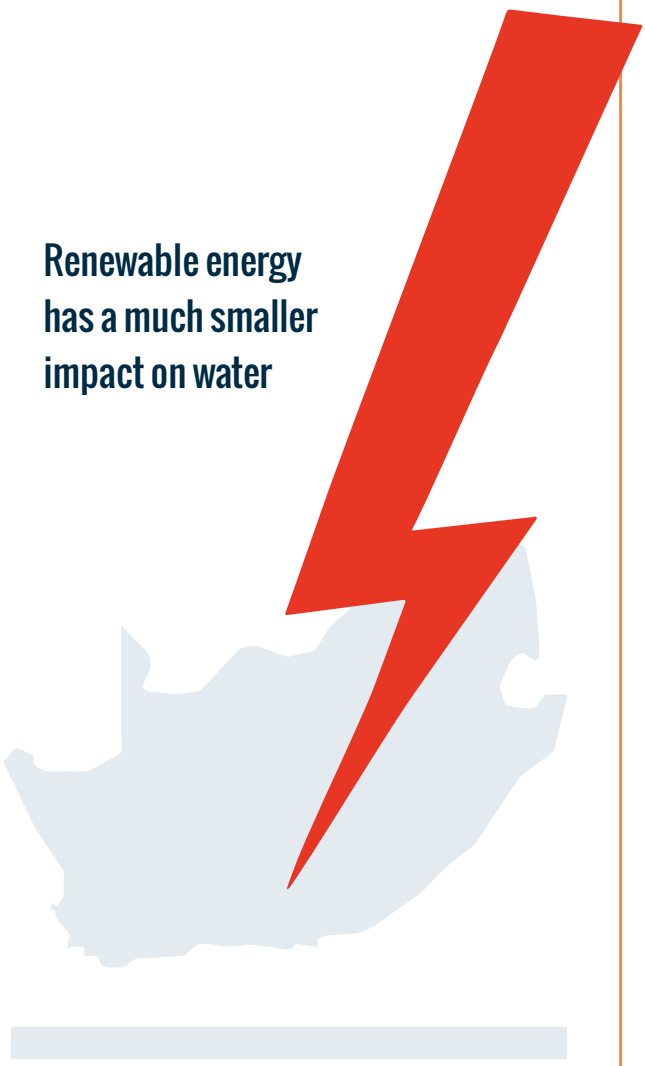
Solar thermal power generation requires lots of direct sunlight – these conditions are usually found in deserts. In South Africa, the area that has been identified for solar thermal power plants is the arid Great Karoo. The water requirements are for steam processes and cooling processes, and a solar thermal power plant can use as much water as a coal power plant. Dry cooling technology can reduce a plant's water use by 95%. An estimate of water use for proposed solar thermal power plants in the Great Karoo (assuming dry cooling technology is used) is approximately 164 million litres per year, or 450 kilolitres per day, for an electricity output of 1500MWh. This amounts to 0.3 litres per kWh, significantly less than coal's 1.38 litres per kWh. There is no downstream pollution There is no downstream pollution associated with this power source.

SOLAR POWER – PHOTOVOLTAIC

Large scale concentrated solar photovoltaic (CPV) requires cooling, and if wet cooling is used, water consumption would be comparable to wet cooling techniques used for other thermal power plants. However it is assumed that CPV in South Africa will use passive cooling or dry cooling technology.

Solar photovoltaic requires the production of silicon, for the manufacture of silicon based solar cells. This involves the mining of quartz sand – with negligible impact on water – and the processing of silicon – with significant consumption of water and energy, and the release of greenhouse gases. Silicon manufacturing also releases fluorine and chlorine into the water supply, and this contaminated water needs to be treated before being released back into water circulation.

Renewable energy has a much smaller impact on water



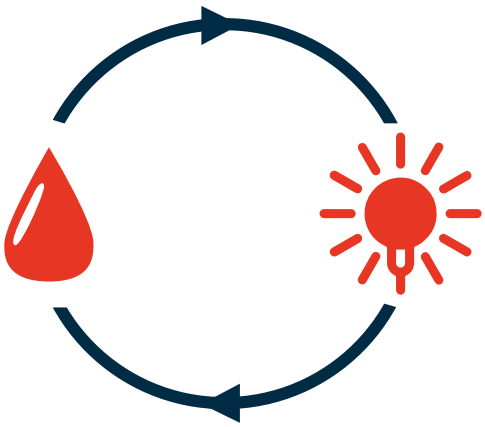
Energy for water production

Electricity is required for every stage in the provision and treatment of water. Our heavy reliance on coal based electricity means that this energy usage for water production carries a significant carbon footprint and contributes to climate change.

A study conducted in Durban estimated that, for every kl of water 'produced' (i.e. stored, distributed and treated), 0.67 kg of CO_2 are emitted[1]. To put this in perspective, 1,08 kg of CO_2 is emitted per 1 kWh of electricity, and 0,3kg of CO_2 is emitted per kilometer in a car. Or, saving 1kl of water is the same as not driving 2,2km!

1 kl H2O = 0,67 kg CO_2[1]

Key Messages



How can we improve efficiency at the heart of the water-energy nexus, while still ensuring energy and water security for all?

Another way of looking at the water-energy nexus is that every unit of water saved, saves energy; and every unit of energy saved, saves water.

- Water supply is not currently seen as a restriction to future energy supplies – this connection needs to be made explicit and should form the basis for future energy decisions
- Coal power has a massive water footprint, especially when you take into account the water used and polluted by mining; this, in addition to the air pollution and greenhouse gas emissions caused by coal, are why it is critical that we wean ourselves off of coal
- ALL energy sources require mining, whether for coal, uranium, rare earth elements, copper or other minerals; and mining always has an impact on water
- As climate change reduces available water, the energy sector will be competing more heavily with other users for water, and it will be in everyone's interest that we invest in energy sources with lower water requirements
- Renewable energy technologies have little impact on water during their operation
- The water sector can reduce its energy footprint by replacing old pumps with energy efficient ones, using solar energy for some of its energy intensive processes, using alternative methods of wastewater treatment, and reclaiming bio-gas from wastewater treatment
- Water managers need public support in order to try new things, such as alternative wastewater treatment
- Put social justice at the heart of transformation of the water energy nexus, for e.g.
    - Reject efficiency or conservation measures that target low income households first
    - Reject false solutions e.g. fracking and water management devices (See EMG fact sheets on these topics)

Resources

1 Friedrich, E., Pillay, S. and Buckley, C. A. 2009. 'Carbon footprint analysis for increasing water supply and sanitation in South Africa: a case study.' Journal of Cleaner Production, Volume 17, Issue 1.

2 Pereira, T. 2009. Climate change mitigation in the water sector. EMG water and climate change research series: Report 1. Available here: http://www.emg.org.za/images/downloads/water_cl_ch/mitigation%20report.pdf.

3 Martin, B. and Fischer, R. 2012. The energy-water nexus: energy demands on water resources. EMG water and climate change research series: Report 5. Available here: http://www.emg.org.za/images/stories/water_cl_ch/water-energy-nexus_to%20print.pdf.

CAPE TOWN HEAD OFFICE

10 Nuttal Road, Observatory
PO Box 13378, Mowbray, 7704, South Africa

+27 (0) 21 448 2881

www.emg.org.za

NIEUWOUDTVILLE FIELD OFFICE

1 Neethling St, Nieuwoudtville,
Northern Cape, South Africa

+27 (0) 27 218 1117

www.emg.org.za

EMG
Environmental
Monitoring Group