# Water use at South Africa's coal power stations: A legal analysis


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## ABSTRACT

South Africa is facing water and energy crises; the demand of which is often in excess of their availability. The water crisis recently culminated into the reality of 'day zero' scares in the city of Cape Town, while planned rolling blackouts, based on a rotating schedule, made 'load shedding' or 'load reduction' regular household terms for South Africans in recent years. South Africa's power utility, Eskom Holdings Limited (Eskom), was initially established in 1923, in terms of the *Electricity Act* 42 of 1922, as the primary generator and supplier of electrical energy. Today, Eskom maintains a varied portfolio of plants, including gas turbines, hydroelectric and nuclear units, as well as coal-fired plants or power stations to produce electricity. Adding to the gloomy reality of failing power plants, from an environmental law perspective, particular concerns emerge as to the quantity of water used at Eskom's coal-fired plants.

Eskom's coal-fired plants are particularly large consumers of water. This is unsettling if one considers the fact that the water catchment areas in which many of Eskom's coal-fired plants are built, are relatively water scarce. While the demand for South Africa's scarce water resources continues to rise, Eskom's water consumption also continues to increase due to the increased demand for electricity. As the country's water reserves diminish, the reality looms that the power utility will in fact not be able to provide any electricity output without water.

This dissertation subsequently focuses on water use at South Africa's coal power stations. More specifically, this dissertation critically examines, from a legal perspective, the sustainability of water use practices at coal fired power stations. In an effort to avoid a compartmentalised approach, which may dismiss and overlook the interconnectedness between water and energy, this dissertation considers the concept of the 'water-energy nexus' to provide some guidance in the analysis. The study subsequently explores how the water-energy nexus can optimise water use in the energy generation process at South Africa's coal-fired power stations from a legal and policy perspective.

**Keywords:**

Water, water use, sustainability, water-energy nexus, coal-fired power stations, governance

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| DEAT | *Department of Environmental Affairs and Tourism* |
| DME | *Department of Energy* |
| DWS | *Department of Water and Sanitation* |
| EIA | *Environmental Impact Assessment* |
| IEP | *Integrated Energy Planning* |
| IWRM | *Integrated Water Resource Management* |
| MEC | *Member of the Executive Council* |
| NDP | *National Development Plan* |
| NEMA | *National Environmental Management Act* 107 of 1998 |
| NEMBA | *National Environmental Management Biodiversity Act* 10 of 2004 |
| NEMWA | *National Environmental Management Waste Act* 29 of 2008 |
| NERSA | *National Energy Regulator of South Africa* |
| NFSD | *National Framework for Sustainable Development* |
| NWA | *National Water Act* 36 of 1998 |
| NWP | *White Paper on a National Water Policy for South Africa* 1997 |
| NWRS | *National Water Resource Strategy* |
| NWRS2 | *National Water Resource Strategy 2* |
| SAHRA | *South African Heritage Resources Agency* |
| WSA | *Water Services Act* 108 of 1997 |

# Chapter 1

# Introduction

## *Background*

South Africa is facing a water and energy catastrophe.[1] Water is an essential, but extremely scarce resource.[2] South Africa, a semi-arid country, is not only plagued by severe hydrological drought conditions, but faces serious challenges to counter the increasing demand and degradation of the already scarce resource.[3] The implementation of water use restrictions is an ongoing reality for the Buffalo City Metro.[4] In fact, 'day zero' was a reality for the City of Cape Town in the year 2018,[5] while 'water shedding' has often been articulated as a possibility in other regions as well.[6] Similarly, the South African electrical energy sector is facing a severely tight demand and supply balance to the extent that 'load shedding' is often implemented.[7]

South Africa's power utility, Eskom Holdings Limited (Eskom), is primarily responsible for supplying electrical energy by maintaining a varied portfolio of plants, which includes gas turbines, hydroelectric, nuclear units, as well as coal-fired plants or power stations. Coal still dominates South Africa's energy supply sector.[8] It is for example

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1 Barradas, Shepherd and Theron *A review of South Africa's water sector* 1. Greenpeace *Water Hungry Coal Burning South Africa's Water to Produce Electricity* 6.
2 Viljoen 2017 *LDD* 176.
3 Barradas, Shepherd and Theron *A review of South Africa's water sector* 1.
4 Buffalo City Metropolitan Municipality *Integrated development review of Buffalo City Metropolitan Municipality* 6,7.
5 Alexander 2018 https://www.bloomberg.com/news/articles/2019-04-12/looking-back-on-cape-town-s-drought-and-day-zero#:~:text=Labelled%20%E2%80%9CDay%20Zero%E2%80%9D%20by%20local,water%20splashed%20across%20news%20sites.
6 Robins 2019 *JSAS* 5.
7 Daniel 2021 https://www.businessinsider.co.za/eskom-load-shedding-worst-case-scenario-for-south-africa-2021-6#:~:text=The%20following%20month%2C%20South%20Africans,by%20Eskom's%20revised%20maintenance%20plans.&text=With%20a%20reduction%20in%20capacity,7%20billion.
8 Greenpeace *Water Hungry Coal Burning South Africa's Water to Produce Electricity* 3,6.

estimated that at least 77 per cent of South Africa's primary energy needs are provided by coal. This process of generating electricity can be summarised as follows:[9]

> Producing electricity from coal starts when the coal is pulverised in huge mills into a fine powder before it is blown into huge kettles, called boilers. Due to the heat in the boiler, the coal particles combust and burn to generate heat to turn water into steam. The steam from the boilers is used to turn the blades of a giant fan or propeller, called a turbine. The turbine turns a coil made of copper wire (the rotor) inside a magnet (the stator). Together they make up the generator. The generator produces an electric current, which is sent to the homes and factories of consumers via power lines.

Coal remains the preferred and primary fuel, for a number of reasons. These include, for example, that South Africa is known for its abundant coal reserves;[10] that coal-fired power stations are relatively reliable;[11] and that South Africa's infrastructure to generation electricity from coal is well established.[12] However, from an environmental law perspective, and from a water law perspective specifically, coal-fired power stations are of particular concern. Apart from the fact that coal as primary fuel produces more waste problems than other energy sources (including sulphur and nitrogen oxides, organic compounds, heavy metals and even radioactive elements),[13] Eskom's coal-fired plants are incredibly water intensive.[14]

Water usage during the coal combustion process at a coal-fired power station not only includes pollution control measures, as noted above, but also for purposes of

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9 Eskom Holdings Ltd 2021 https://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Coal_Power.aspx

10 Greenpeace *Water Hungry Coal Burning South Africa's Water to Produce Electricity* 3,4. Eskom Holdings Ltd 2021 https://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Coal_Power.aspx.

11 Eskom Holdings Ltd 2021 https://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Coal_Power.aspx.

12 Eskom Holdings Ltd 2021 https://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Coal_Power.aspx

13 Jane and Ashton 2018 https://cer.org.za/wp-content/uploads/2018/07/Water-Impacts-and-Externalities-Report_LAC.pdf.

14 Jane and Ashton 2018 https://cer.org.za/wp-content/uploads/2018/07/Water-Impacts-and-Externalities-Report_LAC.pdf. Greenpeace *Water Hungry Coal Burning South Africa's Water to Produce Electricity* 3,4.

purification,[15] cooling,[16] the steam cycle in generation electricity,[17] sluicing of ash,[18] and drainage.[19] As a result, a coal-fired power station, in generating electricity, typically uses more than 10 000 litres of water per second.[20] In fact, during 2005, Eskom used approximately 292 million cubic metres of water for electricity generation only at its coal-fired power stations.[21] In 2010, nearly 640 million cubic metres of freshwater were used. In 2020 the figure was closer to 380 million cubic metres of freshwater used.[22] The intensive use of water is particularly alarming when one observes the fact that the water catchment areas within which many of Eskom's power stations are situated, are relatively water scarce.[23] Clearly, South Africa's electricity, and Eskom's coal-fired power stations in particular, contribute substantially to water pollution and water scarcity, which undeniably jeopardises the country's water insecurity.[24]

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15 Eskom uses eutectic freeze crystallisation for water treatment and purification. During the process water is frozen and salts and impurities are removed from the water. Salts are removed during the cycle and the temperature of the water is restored to ambient. This results in clean water and a dry salt cake that can easily be managed. Eskom Holding Limited *New research technology for water treatment and purification* 1.

16 Cooling can take place via wet cooling or dry cooling. Wet cooling systems use re-circulation; water evaporates via open cooling towers. This system is water intensive, losing 85% of the water supplied to the power station via evaporation. Dry-cooling systems do not rely on open evaporative cooling for its functioning. Eskom Holdings Limited *Water Management* 1.

17 Eskom uses eutectic freeze crystallisation for water treatment and purification. During the process water is frozen and salts and impurities are removed from the water. Salts are removed during the cycle and the temperature of the water is restored to ambient. This results in clean water and a dry salt cake that can easily be managed. Eskom Holding Limited *New research technology for water treatment and purification* 1.

18 Fly ash and coarse ash are stacked on ash dumps or in ash dams (slurry dams). Eskom Holdings Limited *Eskom and ash management* 1.

19 Greenpeace *Water Hungry Coal Burning South Africa's Water to Produce Electricity* 14.

20 Greenpeace *Water Hungry Coal Burning South Africa's Water to Produce Electricity* 8.

21 Eskom Holdings Ltd 2021 https://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/Reduction_In_Water_Consumption.aspx

22 Sanchez, Seliger, Fahl, De Felice, Quarda and Farinosi 2021 *Applied energy* 8.

23 Eskom Holdings Ltd 2021 https://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/Reduction_In_Water_Consumption.aspx.

24 Jane and Ashton 2018 https://cer.org.za/wp-content/uploads/2018/07/Water-Impacts-and-Externalities-Report_LAC.pdf.

### *Problem statement*

Traditionally, and in line with the country's sectoral approach,[25] water and energy have always been regulated by separate legislative branches. There has been little reason to understand the nature of these links, due largely to the presumption that water was not a threat to energy security, nor electricity a threat to water security.[26] This presumption is now being challenged.[27] While we witness an increased demand for electricity, it is expected that Eskom's water consumption will continue to rise. The reality is simple: without water, Eskom will not be able to provide electrical energy.

The severe shortages of resources in the energy and water sectors give rise to pertinent legal questions that necessitate further legal investigation. These include, for example, whether South Africa's water regulatory framework provides for sustainable water use practices in the context of energy generation. The necessity of legally examining water usage at South Africa's coal power stations is exacerbated by the fact that water availability and access thereto are key factors in ensuring a sustainable future for South Africa.[28]

Yet, as indicated above, water is being used at an excessive rate at Eskom's coal-fired coal stations.

It should be noted that water problems associated with coal are however not restricted to Eskom's coal-fired power stations, nor to water depletion or to pollution. It can be extended to coal mines that supply Eskom with coal, especially those that operate without valid water licences.[29] Against the impending water crisis, where unparalleled conditions for conflicts over water rights and access to the increasingly scarce resource loom, Eskom continues to hold that coal-fired power stations are necessary to meet

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25 Thompson *Water law: a practical approach to resource management & the provision of services* 50.

26 Thompson *Water law: a practical approach to resource management & the provision of services* 50.

27 Thompson *Water law: a practical approach to resource management & the provision of services 50.*

28 Algotsson and Murombo *Water supply and sanitation in South Africa: Environmental rights and Municipal accountability* 3.

29 Bega *Mail & Guardian* 1.

the rising electricity demand of the country.[30] Nevertheless, the reality is that while Eskom continues to invest in coal-fired power stations,[31] the power utility puts South Africa's water resources at risk.[32] In order to mitigate this risk, it is necessary to understand and evaluate to what extent the water regulatory framework provides for sustainable water use practices at state owned coal power stations. To define and interpret scientific data related to actual water use for purposes of energy production at coal-fired power stations, falls beyond the scope of this mini-dissertation. Any attempt to do so, rather falls within the field of environmental sciences. Rather, as this study focuses on water use from a legal perspective, this research is limited to legal and policy perspectives related to the sustainability of water use at South Africa's coal fired power stations.

The sustainability of South Africa's water resources are regulated by various legislative measures, including section 27 of the *Constitution of the Republic of South Africa*, 1996 (Constitution);[33] the *National Environmental Management Act* 107 of 1998;[34] the *National Water Act* 36 of 1998 (NWA);[35] and the *Water Services Act* 108 of 1997.[36] Of

30 Currently, South Africa is powered almost completely by coal-fired electricity, as Eskom has thirteen (13) operational coal-fired stations.

31 The power utility is in the process of building a new coal-fired power station in the Nkangala district of Mpumalanga. Kusile will be the fourth-largest coal-fired power station in the world once it is completed. Eskom Holdings Ltd 2021 https://www.eskom.co.za/Whatweredoing/NewBuild/Pages/Kusile_Power_Station.aspx.

32 Greenpeace *Water Hungry Coal Burning South Africa's Water to Produce Electricity* 3.

33 S27(1) of the *Constitution* states that: Everyone has the right to have access to (b) sufficient food and water.

34 S28 of the *National Environmental Management Act* 107 of 1998 establishes the duty of care and remediation of environmental damage. S28(1) reads as follows: Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment.

35 S22 of the *NWA* qualifies 'permissible water use'. (1) A person may only use water (a) without a licence (i) if that water use is permissible under Schedule 1; (ii) if that water use is permissible as a continuation of an existing lawful use; or (iii) if that water use is permissible in terms of a general authorisation issued under section 39; (b) if the water use is authorised by a licence under this Act; or (c) if the responsible authority has dispensed with a licence requirement under subsection (3).

36 S7 of the *Water Services Act* 108 of 1997 regulates the 'Industrial use of water'. 7(1) Subject to (subsection 3) no person may obtain water for industrial use from any source other than the distribution system of a water services provider nominated by the water services authority having jurisdiction in the area in question, without the approval of that water services authority. (2) Subject to subsection (3) no person may dispose of industrial effluent in any manner other than that approved by the water services provider nominated by the water services authority having

specific relevance, is the NWA which specifically aims to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways which take into account the promotion of efficient, sustainable and beneficial use of water in the public interest.[37] This Act is founded on the principle that the National Government has overall responsibility for and authority over water resource management, including the equitable allocation and beneficial use of the scarce and unevenly distributed water resources of the nation.[38]

While this dissertation only focuses on water use at South Africa's coal power stations, one has to be careful of opting a compartmentalised approach, which may dismiss and overlook the interconnectedness between water and energy. Within the context of an energy and water crisis, this mini-dissertation posits that the water and energy sectors are inextricably linked. It follows that water use allocation decisions at coal-fired power stations are becoming more complex. Due to the complexity of the matter,[39] this dissertation considers the concept of the "water-energy nexus" to provide some guidance in the analysis. Against this background, this study determines if, how, and to what extent the South African water regulatory framework safeguards sustainable water use at state owned coal power stations. From a legal and policy perspective, this study is set to systematically explore and utilise the notion of a water-energy nexus to discover and aid sustainable water use practices in South Africa's energy sector.

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jurisdiction in the area in question. (3) A person who, at the commencement of this Act, obtains water for industrial use or disposes of industrial effluent from a source or in a manner requiring the approval of a water services authority under subsection (1) or (2) may continue to do so — (i) for a period of 60 days after the relevant water services authority has requested the person to apply for approval: and (b) if the person complies with a request in terms of paragraph (a) within the 60 day period, until – (i) the application for approval is granted, after which the conditions of the approval will apply: or (ii) the expiry of a reasonable period determined by the water services authority, if the application for approval is refused. (4) No approval given by a water services authority under this section relieves anyone from complying with any other law relating to – (a) the use and conservation of water and water resources; or (b) the disposal of effluent.

37 S2 of the *NWA*.

38 S3 of the *NWA.*

39 Greenpeace *Water Hungry Coal Burning South Africa's Water to Produce Electricity* 3,7,20. Jane and Ashton 2018 https://cer.org.za/wp-content/uploads/2018/07/Water-Impacts-and-Externalities-Report_LAC.pdf.

***Area of focus***

1.3.1 Central research question

The question that underpins this study is how and to what extent the South African water regulatory framework regulates water use at state owned coal power stations for a sustainable water and energy future.

1.3.2 Objectives of the study

The primary objective of this mini-dissertation is to determine how and to what extent the South African water regulatory framework regulates water use at state owned coal power stations for a sustainable water and energy future. In order to achieve this objective, the following secondary objectives are set:

1. To theoretically examine the existing water regulatory framework in relation to water use at South Africa's coal-fired power stations, while considering the overall impacts and the intensive water use for electricity production in South Africa.
2. To discuss the meaning and significance of a water-energy nexus approach in water governance at coal-fired power stations.
3. To assess whether South Africa's water and energy regulatory frameworks provide for nexuses that can contribute towards sustainable water use practices.
4. To distil from the analysis lessons learned, and to make recommendations that can enhance the South African water regulatory framework to sustainably regulate water use at state owned coal power stations.

1.3.3 Assumptions and hypothesis

The following assumptions underlie this mini-dissertation:

1. Sections 24 and 27 of the Constitution afford everyone the constitutional right to a protected environment that is not harmful to their health or well-being, and to have the environment protected from pollution and ecological degradation, which promotes and secures ecologically sustainable

development. The nature and ambit of the environmental right relate to the right of access to sufficient water.

2. The South African Government has the duty to realise the right to a healthy environment and the right to have access to sufficient water.
3. South Africans are heavily dependent on coal-fired power generated by Eskom.
4. Eskom is primarily responsible to generate and supply electricity to South Africa.
5. Various legislative measures exist to concretise the importance of water conservation and the responsible use thereof.
6. Eskom coal-fired power stations are water intensive.

The main hypothesis of this study is that the mobilisation of a water-energy nexus may assist in sustainable water governance decisions being made in terms of the South African water regulatory framework at state owned coal power stations.

### *Research methods*

The research is mainly conducted by means of a desktop literature study. Apart from legislation, the research is conducted with reference to case law, journal articles, policy documents, licences, and relevant information in order to investigate the sustainability of water use at coal power stations in South Africa from a legal perspective. The study starts with a theoretical exposition of relevant legislation and policy measures that make up South Africa's water regulatory framework as it applies to coal fired power stations. It also explores national and international sources on the so-called energy-water nexus. The study subsequently offers a review of South Africa's water and energy regulatory frameworks to determine the extent to which they provide for nexuses that can contribute towards sustainable water use practices. While important pieces of legislation will provide the regulatory framework for energy and water respectively, the research will further investigate the actual enforcement.

### *Framework of this study*

This mini-dissertation is organised into five chapters. The present chapter provides the background to the research question, the problem under discussion and a description of the research methods.

Chapter 2 examines, from a legal perspective, what the water allocation and management or regulatory framework relevant to coal fired power stations of South Africa entail. The analysis is expected to provide a clearer view of South Africa's water regulatory framework, legal compliance, enforcement and monitoring mechanisms, as well as other forms of legal interventions in relation to water use at coal-fired power stations in the country. Hereby, this chapter is set to provide a benchmark against which responsible and sustainable water use during energy generation can be measured.

Chapter 3 introduces and considers the notion of the 'water-energy nexus' to emphasise the interconnectedness between water and energy. The aim of the analysis is to determine whether more sustainable practices, notions or measures exist that may enhance water allocation and management at state owned coal power stations.

Chapter 4 examines, by using the water-energy nexus, potential nexuses in South Africa's water and energy regulatory frameworks that can be utilised and implemented at South Africa's coal-fired power stations to develop or enhance sustainable water use practices.

Chapter 5 critically discusses the implications of the water-energy nexus for sustainable water use practises as coal-fired power stations. The chapter summarises the findings and serves as the basis to assess whether and to what extent the South African water regulatory framework regulates water use at state owned coal power stations and to recommend ways of clarifying and addressing poor governance.

# Chapter 2

# Theoretical foundations: South Africa's water regulatory framework as applicable to coal fired power stations

## *2.1 Introduction*

Water is a vital, but extremely scarce natural resource. This is particularly true for South Africa, the 30th driest country in the world.[40] South Africans face major water challenges.[41] In fact, according to studies, at least 2.11 million people in South Africa do not have access to water.[42] Against this background, this mini-dissertation identifies and addresses concerns about the use of South Africa's limited water resources in the energy sector. It is trite that coal fired power stations need water to generate electricity.[43] In fact, all types of electricity generation consume water, whether it is to process the raw materials used in the facility, or fuel, or to construct and maintain the plant, or to just generate the electricity itself.[44] It is alarming, however, how much of this scarce natural resource is actually being used in the electricity generation process at coal fired power stations.[45] Eskom accounts for about 1.5 per cent of the country's total water consumption annually.[46] Apart from the excessive water use, the already scarce water resource is being polluted at coal fired power stations.[47] It needs little further explanation that Eskom is indeed accelerating South Africa's water crisis.

It follows that the power generation sector should urgently minimise its demand and impacts on the scarce water resources. From a legal perspective, one way of minimising the impact, is to apply an effective water governance framework to using

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40 WWF 2021 https://www.wwf.org.za/our_work/water/. Munnik *Water risks of coal driven mega projects in Limpopo: the MCWAP and the EMSEZ* 17.
41 Viljoen 2017 *LDD* 176.
42 Edokpayi, Rogawski, Kahler, Hill, Reynolds, Nyathi, Smith, Odiyo, Samie, Bessong and Dillingham 2018 *Water* 2.
43 Jane and Ashton 2018 https://cer.org.za/wp-content/uploads/2018/07/Water-Impacts-and-Externalities-Report_LAC.pdf.
44 Jane and Ashton 2018 https://cer.org.za/wp-content/uploads/2018/07/Water-Impacts-and-Externalities-Report_LAC.pdf.
45 Greenpeace *Water Hungry Coal Burning South Africa's Water to Produce Electricity* 3.
46 Eskom Holdings Limited *Water Management* 1.
47 Earth Justice 2021 https://earthjustice.org/cases/2014/cleaning-up-power-plant-water-pollution.

water at coal-fired power stations. This chapter therefore uses a legal and policy lens to firstly analyse the existing governance structures in relation to water use at South Africa's coal-fired power stations. The analysis is expected to provide a clearer view of South Africa's water regulatory framework, legal compliance, enforcement and monitoring mechanisms, as well as other forms of legal interventions in relation to water use at coal-fired power stations in the country.

This chapter is structured into three main parts. The first part provides a general understanding of the water demand and water-related activities at coal fired power stations. Part two continues to theoretically dissect the governance framework for such water use. This part is set to explain legal perspectives to legitimate water use, legal compliance, enforcement and monitoring mechanisms, as well as other forms of legal interventions in relation to water use at coal-fired power stations in the country. Part three provides a critical summary of the main findings of the chapter and take a stance on the *status quo* of water use at South Africa's coal fired power stations that can be used as a benchmark against which responsible and sustainable water use during energy generation can be measured in the following chapters.

## *2.2 A general understanding of the water needs at coal fired power stations*

In light of the gloomy picture painted in the introductory paragraph, it is concerning that research shows poor data on the exact volumes of water demands within the energy sector.[48] As this study is a literature study, and firmly set in the discipline of law, this section uses existing and available literature and reports that previously estimated the demand, and extent of water withdrawal and consumption for electricity production. While this section is set to provide a general understanding of water demand at coal fired power stations, it is also expected to show that the available data on water usage at South Africa's power stations are inadequate in their detail and availability.

48 Larsen, Petrovic, Engstrom, Drews, Liersch, Karlsson and Howells 2019 *Energy Strategy Reviews* 2045.

The demands for water at Eskom's power stations are varied. Processes that are dependent on water are: cooling,[49] ash handling and disposal,[50] drainage and sewage treatment.[51] This wastewater is then discharged into ash slurry dams, containing coal ash.[52] However, the main demands for water within a coal fired power station plant are for the steam cycle[53] and cooling processes.[54]

### 2.2.1 Steam cycle

Water at Eskom's power stations is in demand mainly for steam condensation. The power station converts energy from coal to steam in order to drive turbine generators. The steam is then condensed and the process is repeated.[55] Steam recycling is a critical aspect in the process, as the condensate must be reduced in temperature as much as possible in order to reduce the backpressure on the turbine.[56] The demand for water in the steam cycle is illustrated by one case example. One of Eskom's power stations, Duvha, situated in Mpumalanga Province, uses about 2 mega litres of water daily in its steam cycle.[57]

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49 See above in Chapter one. Eskom Holdings Limited *Water Management* 1.

50 See above in Chapter one. Eskom Holdings Limited *Eskom and ash management* 1.

51 Eskom uses a zero liquid effluent discharge (ZLED) at its wet cooled power stations. "Water is cascaded from good to poor quality uses, until all pollutants are finally captured in the ash dams." Eskom Holdings Limited *Water Management* 2.

52 Steele *Water hungry coal: burning South Africa's water to produce electricity* 14.

53 Wassung explains that "In the internal steam cycle of a coal power plant, demineralised water is piped above a boiler where the coal is burnt, and the heat turns the water to steam. The steam then turns a turbine to generate electricity. As the steam passes through the turbine it is fed into a condenser, which transforms the steam back into water." Wassung *Water scarcity and electricity generation in South Africa* 18.

54 Coal fired power plants require cooling for its machinery to operate efficiently. Additionally, cooling is used to condense steam originating from the turbines. Wassung *Water scarcity and electricity generation in South Africa* 18.

55 National Energy Technology Laboratory 2021 https://www.netl.doe.gov/research/Coal/energy-systems/gasification/gasifipedia/water-usage.

56 National Energy Technology Laboratory 2021 https://www.netl.doe.gov/research/Coal/energy-systems/gasification/gasifipedia/water-usage.

57 This is the equivalent to 0.034 litres of water used per kWh of electricity produced. Wassung *Water scarcity and electricity generation in South Africa* 18.

### 2.2.2 Cooling process

Power plants primarily use one of two systems to cool the plant, namely wet[58] and dry[59] cooling systems.[60] Cooling with water at coal fired power plants occurs either by way of open-loop (once-through)[61] or by way of closed-loop (re-circulating):[62]

> Compared to re-circulation, once-through cooling is more energy efficient and lower in infrastructure and operational costs; however, the ejected water is warmer than ambient water, which can kill fish and damage aquatic ecosystems. The amount of heat ejected is related to the thermal efficiency of the power plant: the higher its thermal efficiency, the lower the water usage. Re-circulated cooling requires less water withdrawal because the water is recycled through the use of cooling towers or evaporation ponds, but water consumption is higher due to evaporation in the process. Cooling with air (dry cooling) requires the use of industrial fans, and is a less energy-efficient solution. Capital costs are also higher, and more land is necessary to house the additional machinery needed. Currently only four coal-fired power plants in South Africa use dry cooling (or a combination of wet and dry) due to their location in water-scarce areas. [63]

However, although these descriptions provide a general understanding of the demand for water at coal-fired power stations, the exact and accurate data on actual volumes of water within the energy sector is scarce.[64] In fact, available figures at coal fired power stations only account for extraction of fresh water and excludes dirty or reused water.[65] This exclusion negatively affects the accuracy of data, as air-pollution control on power plants also require water and needs to be reckoned with when calculating

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58 Wet cooling systems 'dissipate heat to the atmosphere either by recirculating water through a cooling tower or by constantly replenishing an evaporative cooling pond'. This happens by once-through cooling, or by wet recirculating cooling towers. Global Energy Monitor 2021 https://www.gem.wiki/Water_consumption_from_coal_plants.

59 Dry cooling uses no water. Global Energy Monitor 2021 https://www.gem.wiki/Water_consumption_from_coal_plants.

60 Global Energy Monitor 2021 https://www.gem.wiki/Water_consumption_from_coal_plants.

61 Once-through cooling withdraws water for one use only before returning most of it to the source, although a significant amount of the water withdrawn is lost to evaporation. Wassung *Water scarcity and electricity generation in South Africa* 18-20.

62 In the re-circulating process, water is usually withdrawn from an available source and then sprayed down cooling towers, which make use of evaporation within the chimneys to cool the water. *Water scarcity and electricity generation in South Africa* 18-20.

63 Wassung *Water scarcity and electricity generation in South Africa* 18-20. King and Webber 2008 *Nature Geoscience* 283,284. Apfelbaum, Duvall, Nelson, Mensing, Bengtson, Eppich and Thompson *Wetland water cooling partnership: the use of constructed wetlands to enhance thermoelectric power plant cooling and mitigate the demand of surface water use* 11.

64 Larsen, Petrovic, Engstrom, Drews, Liersch, Karlsson and Howells 2019 *Energy Strategy Reviews* 2045.

65 Wassung *Water scarcity and electricity generation in South Africa* 19.

water volumes. Such pollution control, using water, can be described as dust suppression. Coal ash is stacked onto ash plants and sprayed with water for dust suppression.[66] The coal-fired power station of Duvha, for example, uses 0.9 litres of water per kWh for ashing purposes.[67] Clearly, these demands should be reckoned with, and included into volume calculations. Therefore, although it is difficult to determine exact volumes of water needs, existing studies attempted to project total water use volumes. Wassung[68] for example projects the perceived total water need at an average coal fired power plant like Duvha as:

> 0.034 ℓ/kWh (internal steam cycle) + 2.13 ℓ/kWh (cooling) + 0.9 ℓ/kWh (air pollution control) + 0.022 ℓ/kWh (disposal of by-products) = 3.086 ℓ/kWh.[69]

From 2013 to 2020 the average figure for water demands at coal fired power stations was between 360 000 mega litres and 370 000 mega litres.[70] In 2017 Eskom's coal fired power stations used approximately 841 million litres of water per day to generate electricity, that is the equivalent of 10 000 litres per second being used.[71] It is important to note that these figures are 'averages' and 'estimates', and that there are no exact figures for each individual power station in the country. Thus, as clear from the above, available data on water demands in South Africa's energy-sector are particularly scant. The discussion, although limited and brief, is however relevant to the extent that it highlights the large amount of water that is being used and polluted. This reality imposes serious risks on society that depends on water for their daily lives.

Notably, Eskom has shared its commitment towards an environmental duty of care in its sustainability performance index.[72] As part thereof, Eskom has included certain strategic objectives, including "reducing freshwater usage" and to "avoid impacting water resources through effective water management processes", for example.

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66 Wassung *Water scarcity and electricity generation in South Africa* 19,20.
67 Wassung *Water scarcity and electricity generation in South Africa* 19,20.
68 Wassung *Water scarcity and electricity generation in South Africa* 20.
69 Wassung *Water scarcity and electricity generation in South Africa* 20.
70 Thopil and Pouris *Applied energy* 2816.
71 Jane and Ashton 2018 https://cer.org.za/wp-content/uploads/2018/07/Water-Impacts-and-Externalities-Report_LAC.pdf.
72 Eskom Holdings Limited 2021 https://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/Sustainable_Development_Overview.aspx.

Naturally, this is merely a commitment, and the question emerges whether the country's existing governance framework can impose legal compliance, enforcement and monitoring mechanisms to curb water use at coal fired power stations.

## *2.3 Legal governance structure for water use at South Africa's coal-fired power stations*

The Food and Agriculture Organisation of the United Nations defines water governance as:

> the enabling environment in which water management actions take place: that is, the overarching policies, strategies, plans, finances and incentive structures that concern or influence water resources; the relevant legal and regulatory frameworks and institutions; and planning, decision-making and monitoring processes.[73]

In South Africa, the legal or regulatory framework forms the basis of the governance framework. The regulatory framework provides for the authority to create policy documents for strategies, plans and financial interventions, for example. The law further provides the necessary authority to carry out planning, to strategise, and to guide decision-making. The law is therefore pertinent in understanding Eskom's strategic objectives, as noted above. In fact, the law ultimately ensures that there is compliance to legal requirements.[74] As the legal framework is such an important aspect of the governance framework, the South African legal framework forms the focus of this section.

### 2.3.1 The legal framework in South Africa

#### 2.3.1.1 Introductory remarks

South Africa's constitutional structure involves three spheres of government: national, provincial and local.[75] The overall governance of water is an exclusive national competence in terms of the *Constitution of the Republic of South Africa*, 1996

73 Food and Agriculture Organization of the United Nations 2017 http://www.fao.org/3/i7959e/i7959e.pdf. Kidd "Water governance, management and use" 115.
74 Kidd "Water governance, management and use" 115.
75 S40 of the *Constitution*, 1996.

(Constitution), and this responsibility is carried out by the national Department of Human Settlements, Water and Sanitation.[76] The responsibilities are fleshed out by an array of international and national policies, known as soft law[77] instruments, as well as binding law. The focus of this chapter necessitates an examination of national legal instruments, including the *Constitution of the Republic of South Africa*, 1996 (Constitution);[78] the *National Environmental Management Act* 107 of 1998 (NEMA);[79] the *National Water Act* 36 of 1998 (NWA);[80] and the *Water Services Act* 108 of 1997 (WSA).[81] A theoretical exposition of the country's water regulatory framework is needed to promote judicious water use and is expected to guide Eskom's coal power stations to navigate its water use practices to full compliance.

#### 2.3.1.2 The Constitution

The *Constitution* provides for fundamental human rights in Chapter 2, including a basic right to an environment that is not harmful to the health or well-being of South African inhabitants,[82] and it awards the right to access to sufficient water.[83] This means that there is a positive duty upon the State to protect environmental rights and progressively realise rights within available resources,[84] and a negative duty upon the State not to interfere with these rights. Various pieces of legislation have been passed according to this mandate, some of which will be discussed hereafter.

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76 The *Constitution of the Republic of South Africa*, 1996.
77 'Soft law' refers to non-law, it is not a source of law but is legally relevant. It can be described as non-binding coercions. Olivier 2002 *CILJSA* 289. Zerilli 2010 *Journal of Global and Historical Anthropology* 3.
78 The *Constitution of the Republic of South Africa*, 1996.
79 The *National Environmental Management Act* 107 of 1998.
80 The *National Water Act* 36 of 1998.
81 The *Water Services Act* 108 of 1997.
82 S24 of the *Constitution*, 1996.
83 S27(1)(b) S24 of the *Constitution*, 1996. Internationally, UN General Comment No 15 outlines the right to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use. A2 of the CESCR General Comment No 15 *The right to water* 1.
84 S7(2) of the *Constitution*, 1996.

#### 2.3.1.3 The Water Services Act 108 of 1997

The right of access to sufficient water, as envisaged by the *Constitution*, is given legislative effect by the *WSA*.[85] The long title of the Act stipulates its aim. The Act is set to provide for the rights of access to water supply, setting national norms and standards and monitoring water services. For purposes of this study, it is necessary to briefly refer to at least two different legislative notions or measures, being the notion of 'water service institutions', and the idea of Eskom being an 'industrial user of water'. Most of Eskom's coal fired power stations treat raw water[86] to produce potable water for certain processes, and to supply water to the nearby communities and tied collieries for domestic purposes, as a water use mitigation effort.[87] In terms of the *WSA*, such power stations are then classified as 'water service institutions', meaning that the power stations can function as a water services authority, a water services provider, a water board, or a water services committee.[88] As a water services institution, a power station is expected to comply with the regulations of this Act.

Section 1 of the *WSA* further classifies Eskom's coal fired power stations as 'industrial users'. This means that the power stations may make use of water for, amongst others, the generation of electricity.[89] The Act states that for the industrial user of water, it may not be obtained from any source other than the distribution system of a water services provider.[90] This means that water for industrial use may only be obtained with a permit from the relevant authority.

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85 Viljoen *Water as public property: a parallel evaluation of South African and German law* 176. Fuo 2013 *Murdoch University Law Review* 27. S3(1) of the *WSA* 108 of 1997.

86 Such treatment consists of recycle and reuse practices like Zero Effluent Discharge; recycling cooling water; recovery and reuse ash water; recovery and reuse station drains; recovery of treated mine-water; and recovery of treated sewage reuse. Eskom Risk & Sustainability Division 2018 https://www.eskom.co.za/AboutElectricity/FactsFigures/Documents/ENV/WaterRe-UseRecyclePowerPlants.pdf.

87 Eskom Risk & Sustainability Division 2018 https://www.eskom.co.za/AboutElectricity/FactsFigures/Documents/ENV/WaterRe-UseRecyclePowerPlants.pdf.

88 S1 (xxi) of the *WSA* 108 of 1997.

89 S1(ix) of the *WSA* 108 of 1997.

90 S7(1) and (4) of the *WSA* 108 of 1997.

#### 2.3.1.4 The National Water Act 36 of 1998

The purpose of the *NWA* is to ensure that South Africa's water resources are protected, used, developed, conserved, managed and controlled.[91] Therefore, the National Government acts as public trustee of the nation's water resources to ensure water is used in a sustainable and equitable manner, for the benefit of all persons and in accordance with the constitutional mandate.[92] This can be achieved if, basic human needs are met;[93] equitable access to water is realised;[94] water use is efficient, sustainable and beneficial and in the public interest;[95] the growing demand for water use has to be considered;[96] ecosystems should be protected;[97] and the reduction and prevention of pollution and degradation of water resources must be avoided.[98] The Act requires that when a water resource is polluted, the landowner must take reasonable steps to prevent pollution from occurring again or from continuing.[99] The Act lists the reasonable steps to be taken and these include: to find, contain and remedy the source of the pollution; to comply with existing waste management practices; and to contain or prevent the movement of pollutants.[100]

Significantly, the *NWA* offers the regulatory framework for water use. Water use in terms of the *NWA* includes taking, storing or diverting water from a water resource; engaging in a stream flow reduction or controlled activity; discharging wastewater into a water resource, including water containing waste from any industrial or power generation process or water found underground; disposing of waste in a manner which may detrimentally impact on a water resource; and altering the bed, banks, course or characteristics of a watercourse.[101]

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91 Preamble to the *NWA* 36 of 1998.
92 S3(1) of the *NWA* 36 of 1998.
93 S2(a) of the *NWA* 36 of 1998.
94 S2(b) of the *NWA* 36 of 1998.
95 S2(d) of the *NWA* 36 of 1998.
96 S2(f) of the *NWA* 36 of 1998.
97 S2(g) of the *NWA* 36 of 1998.
98 S2(h) of the *NWA* 36 of 1998.
99 S19(1) of the *NWA* 36 of 1998.
100 S19(2) of the *NWA* 36 of 1998.
101 S21 of the *NWA* 36 of 1998.

The above-mentioned water uses are only allowed if there is an existing water use license. Water use includes engaging in a controlled activity;[102] this 'activity' includes power generation which alters the flow regime of a water resource.[103] An institution can only be entitled to use water if the use is permissible under the *NWA.* The Act provides these access rights in the form of licenses and permits,[104] subject to certain conditions.[105] Water may be used,[106] subject to a water use licence,[107] unless the use is permissible under Schedule 1 of the Act, a continuation of an existing lawful use, or in terms of a general authorisation.[108]

In terms of the Act, water use licenses can be retracted if the license holder fails to comply with any condition, fails to comply with the Act or fails to pay a charge which is payable in terms of Chapter 5 of the Act.[109] A water use license can also be subject to remedial action,[110] if there is non-compliance with the conditions.[111] Remedial action happens by way of notification in writing to the holder of a water use license. Non-compliance can include the contravention of a requirement, directive or condition which applies to the license holder in terms of water use. The license holder, or the owner of the property, can be directed to take any action specified in the notice to rectify the contravention, within the specified time. The license holder or owner of the property then has to take action within the time specified in the notice. If the license holder or owner of the property then fails to take the necessary action timeously, the relevant authority may take any action necessary to rectify the contravention and recover its reasonable costs from the person on whom the notice was served.

Chapter 5 of the *NWA* called from the development of the *National Water Resource Strategy* (2004) (*NWRS).* The objective of the first *NWRS* is based on water resource

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102 S21(e) of the *NWA* 36 of 1998.
103 S37(1)(c) of the *NWA* 36 of 1998.
104 Viljoen *Water as public property: a parallel evaluation of South African and German law* 194.
105 S28(1)(d)-(e) of the *NWA*.
106 S22(1)(a)(i)-(iii) of the *NWA* 36 of 1998.
107 S22(1)(b) of the *NWA* 36 of 1998.
108 S4(3) of the *NWA* 36 of 1998.
109 S54 of the *NWA*.
110 S53(1)(a)-(c) and S53(2)(a) of the *NWA*.
111 S53-55 of the *NWA*.

management to ensure sustainable social and economic development.[112] The purpose of the *NWRS* 2 is to provide a framework for the protection, use, development, conservation, management and control of the nation's water resources.[113] The strategy is binding on all authorities and institutions exercising powers or performing duties under the *NWA*.[114] The *NWRS* classifies Eskom as a 'strategic water user',[115] because of to the central role of electricity in the economy and development of the country. This is particularly relevant especially in times of economic hardship during the Covid-19 lockdown.[116] Eskom's Environmental Management Strategy also mentions the power utility's status as a strategic water user and states that the company strives for water management challenges to be addressed through participation in initiatives such as research, the establishment of water management policies, and the implementation of efficient water practices, to promote and improve effective and efficient use of water by the power stations.[117] Being a strategic water user means that Eskom is guaranteed 99.5% water availability and is therefore accountable to use water responsibly.[118] The *DWS* requires that the Minister of Human Settlements, Water and Sanitation must publish regulations according to section 26 of the *NWA*,[119] to limit and monitor water abstraction for irrigation purposes.[120] However, no such limitations are placed on Eskom's coal-fired power stations.[121]

The *NWRS* 2 require that the *IWRM* (Integrated Water Resource Management) be implemented in South Africa. The *IWRM* approach traces its origins to the Dublin

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112 Department Water Affairs & Forestry *NWRS* i.
113 Preamble to Part 1 of Chapter 2 of the *NWA* 36 of 1998.
114 Department Water Affairs *NWRS2* 7.
115 S6(1)(b)(iv) of the *NWA* requires the *NWRS* to make provision for water uses of strategic importance. Department Water Affairs *NWRS2* 7. *NWA* 37 of 1998.
116 Lapping 2020 https://businesstech.co.za/news/business-opinion/396879/the-economic-cost-of-south-africas-lockdown/.
117 Eskom Holdings 2014 https://cer.org.za/wp-content/uploads/2018/05/Doc-1.3-a-Esk-env-strat-aug-14.pdf.
118 De Bod *The South African water management framework: Lethabo power station as a case study* 15.
119 S26 of the *NWA* 36 of 1998.
120 Department of Water and Sanitation 2016 https://www.gcis.gov.za/sites/default/files/docs/resourcecentre/yearbook/WaterSanitation-SAYB1516.pdf.
121 See section 2.3.2.3 above.

principles.[122] The first document pertaining to water law under the new South African regime was the *White Paper*, setting out the principles of the water reform.[123] Then, as discussed above, came the *Water Services Act*,[124] followed by the *National Water Act*.[125] It was during this time of reform that the *IWRM* was brought to life in South Africa.[126]

In 2002 the World Summit on Sustainable Development requested all countries to draft and implement *IWRM* and water efficiency strategies.[127] To date, more than 80% of countries have *IWRM* principles in their water laws.[128] The *IWRM* imposes a set of principles and tools,[129] it promotes the coordination and integration of management of the physical environment within the broader socio-economic and political framework, without compromising the sustainability of resources.[130] The approach focuses on institutional roles and responsibilities, and management instruments. Claassen describes the *IWRM* as a policy enabler, regulating the environment and water resources. The *NWA* has adopted the principles of *IWRM*.[131]

The approach, however, is only focused on water, by being monocentric and exclusive of other sectors.[132]

#### 2.3.1.5 Non-sector specific legislation

The *NWA* and the *WSA* are sector specific legislation in terms of water. However, non-sector specific legislation, such as the National Environmental Management Act 107 of 1998 (NEMA), National Environmental Management Biodiversity Act 10 of 2004

122 Dublin-Rio Principles "The Dublin Statement on Water and Sustainable Development" 1-3.
123 *White Paper on a National Water Policy for South Africa* (NWP).
124 *WSA* 108 of 1997.
125 *NWA* 36 of 1998.
126 Movik, Mehta, van Koppen and Denby *Water Alternatives* 458.
127 United Nations "Report of the World Summit on Sustainable Development" 1-166.
128 Allouche *Water Alternatives* 412.
129 Allouche *Water Alternatives* 416.
130 Claassen 2013 *International Journal of Water Governance* 323. Global Water Partnership 2011 https://www.gwp.org/en/GWP-CEE/about/why/what-is-iwrm/.
131 Madigele, Snowball and Fraser 2015 *International Journal of Water Governance* 1.
132 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15.

(NEMBA) and National Environmental Management Waste Act 59 of 2008 (NEMWA) also contain relevant principles in terms of water use, protection and pollution. *NEMA* includes water in its definition of the environment[133] and section two requires pollution prevention principles[134] as well as the polluter pays principle to be implemented by all industries in the country, including Eskom.[135] *NEMA* also contains the duty of care and requires everyone who has caused pollution or degradation to the environment to take reasonable steps to prevent such pollution from continuing or recurring in the future.[136] The principle further requires that in so far as harm to the environment is authorised by law or cannot reasonably be avoided or stopped, the pollution or degradation must be minimised and rectified by the polluter.[137] Similarly, *NEMWA* is concerned with pollution prevention and conservation of natural resources. The Act provides measures to minimise the consumption of natural resources, to prevent pollution and ecological degradation[138]

The polluter pays principle, pollution prevention principle, and the duty of care, apply to all industries, including Eskom's coal fired power stations.[139] The power utility must implement measures to prevent and mitigate water pollution, increase conservation, and decrease waste production. Such would include using less water to generate electricity and decreasing water pollution and waste production by adopting cleaner technology and investing in renewable energy.

### *2.4 South Africa's coal fired power stations: The status quo*

Against the backdrop of the water regulatory framework, it is important to consider the *status quo* of legitimate water use at South Africa's coal fired power stations. The goal of this short analysis is to determine if power stations, when it comes to water usage, operate in line with the regulatory framework. To do so, different power stations varying in age, location, operational capability and size where chosen. These

133 S1 of *NEMA* 107 of 1998.
134 S 2(4)(ii) of *NEMA* 107 of 1998.
135 S 2(4)(p) of *NEMA* 107 of 1998.
136 S28(1) of *NEMA* 107 of 1998.
137 S28(1) of *NEMA* 107 of 1998.
138 S 2(a)(i) and (iv) of *NEMWA* 59 of 2008.
139 S2(1) of *NEMA* 107 of 1998.

power stations represent Eskom and its "compliance" with water and waste regulations.

Existing studies found that Eskom's Lethabo power station has stored wastewater without a water use license,[140] contravening section 19 and 37 of the *NWA,* as this is listed as a controlled activity.[141] The Matimba power station has caused surface-water and ground-water pollution due to a lack of lined dams,[142] once again contravening section 19 and 37 of the *NWA*.[143] The Camden power station has discharged contaminated water into the surrounding environment,[144] contravening section 19 and 37(d) of the *NWA*. In 2020, Tutuka power station has breached its water use licenses, leading to surface-water and ground water pollution,[145] contravening section 19 and 37(d) of the *NWA*. At Duvha power station it was discovered that a water-use license had been absent for its water uses. In addition, at Duvha, coal waste and sludge were dumped in unlined ash dams.[146]

From these reports, it is evident that Eskom's power stations have a history of non-compliance with the country's water regulatory framework. In fact, on the one hand, the power utility has virtually unlimited access to water resources as a strategic water user, and on the other, it often operates, and without repercussion, without a water licence, or where a water use licence is in place, evidence shows instances of contraventions to existing license conditions.

## *2.5 Concluding remarks*

This chapter has provided a general understanding of water demand and use at Eskom's coal fired power stations. Against the above it is clear that South Africa has

140 Van Schie 2012 https://www.iol.co.za/news/eskoms-shocking-environmental-record-1429715.
141 S19 and 37 of the *NWA* 36 of 1998.
142 Van Schie 2012 https://www.iol.co.za/news/eskoms-shocking-environmental-record-1429715.
143 S19 and 37 of the *NWA* 36 of 1998.
144 Van Schie 2012 https://www.iol.co.za/news/eskoms-shocking-environmental-record-1429715.
145 Sguazzin 2020 https://www.bloomberg.com/news/articles/2020-11-12/eskom-ordered-to-rectify-pollution-issues-at-three-power-plants.
146 Sguazzin 2020 https://www.bloomberg.com/news/articles/2020-11-12/eskom-ordered-to-rectify-pollution-issues-at-three-power-plants.

a comprehensive, seemingly sufficient water regulatory framework. It consists of binding and non-binding legal instruments, the most relevant for current purposes being the *Constitution*, the *WSA,* and the *NWA*. These Acts all state the importance of protecting the environment and the country's natural water resources, to ensure sustainable development and available resources for future generations.

It is the responsibility of The Department of Water and Sanitation to protect and regulate the country's water resources, to implement effective policies and to integrate strategies. The Department must plan and follow legislative requirements pertaining to water-related policies and legislation, like the *Constitution* and water related Acts.[147] The *DWS* requires regulations to be published in terms of the *NWA*,[148] in order to limit and monitor water abstraction for irrigation purposes.[149] Disturbingly, these limitations have not been placed on Eskom's coal-fired power stations.[150]

As the case studies have indicated, Eskom is not only underperforming (resulting in load shedding), but the power utility often operates without a valid water licence.[151] In fact, where a water use licence is in place, it seems from the case studies above that the licence holders contravene the condition(s) of the licence by either polluting water or using water in excess of what is allowed. The poor regulation of water at coal fired power stations in South Africa may to some extent be due to a lack of law enforcement. However, there may be more to the dire reality than meets the eye. As will be indicated in more detail in subsequent chapters, this study explores and utilises the notion of a water-energy nexus to discover and aid sustainable water use practices in South Africa's energy sector.

147 Department of Water and Sanitation 2016 https://www.gcis.gov.za/sites/default/files/docs/resourcecentre/yearbook/WaterSanitation-SAYB1516.pdf.
148 S26 of the *NWA* 36 of 1998.
149 Department of Water and Sanitation 2016 https://www.gcis.gov.za/sites/default/files/docs/resourcecentre/yearbook/WaterSanitation-SAYB1516.pdf.
150 See section 2.3.2.3 above.
151 Wassung *Water Scarcity and Electricity Generation in South Africa* 6.

# Chapter 3

# The meaning and significance of a water-energy nexus approach in water governance at coal-fired power stations

## *3.1 Introduction*

The first chapter of this dissertation introduced and conceptually described the concepts of 'water-shedding' and 'load-shedding' that have emerged to become part of every South African's life. These concepts represent deep and critical issues not only in South Africa's water, but also in the country's energy sector. In the quest to demystify some of these issues, chapter 2 has assessed the water regulatory framework that is set to govern water use or consumption at South Africa's coal fired power stations. Whilst the existing regulatory framework currently aims to *inter alia* protect water resources through various measures, for example, including water licenses and permits, the preceding chapter has provided evidence that the country's power utility (Eskom) falls short of legislative implementation in the form of non-compliance.

Given the high demand for water needed for the generation of energy at coal-fired power stations, especially when compared to most renewable wind, solar and geothermal plants,[152] South Africa's water and energy sectors are set for a disaster. In fact, not only has climate change already begun to affect precipitation,[153] but water scarcity and variability, add unique challenges to the vulnerability of South Africa's energy sector.

In an attempt to better conceptualise and respond to such challenges, this chapter theoretically observes the so-called water-energy nexus. The first part of this chapter argues that the nexus approach stems from the realisation that water and energy

152 National Academy of Sciences, National Academy of Engineering, and National Research Council. "Renewable electricity generation technologies" 67, 68, 77, 86.

153 US Department of Energy 2014 https://www.energy.gov/sites/default/files/2014/07/f17/Water%20Energy%20Nexus%20Executive%20Summary%20July%202014.pdf.

exhibit strong interlinkages, but that the said resources are traditionally governed under a sectoral approach. As chapter 2 has suggested, any attempt to achieve resource security independently, often endangers sustainability and resource security.[154] Part two theoretically dissects the essence of the water-energy nexus and argues that it is three dimensional; that it can be used as an analytical tool, a conceptual framework, or a scholarly discourse. As an analytical tool, the nexus systematically applies quantitative and qualitative methods to understand the interactions among water and energy resources; as a conceptual framework, it simplifies an understanding of water and energy linkages to promote coherence in policymaking and enhances sustainable development; and as a discourse, it is aimed at problem framing and promoting cross-sectoral collaboration. The chapter concludes with brief reflections on the potential of the water-energy nexus in water governance at coal-fired power stations. The latter also provides a useful point of departure for chapter 4, which will, in more detail, discuss the meaning and significance of a water-energy nexus approach in water governance at coal-fired power stations.

### *3.2 Historical reflections*

Historically, many countries have enjoyed the use of abundant water resources.[155] As water was presumably not a threat to energy security, nor energy a threat to water security, there has been little reason to understand the link or nexus between water and energy.[156] Rather, where water shortages have not been a pressing issue, water and energy systems were largely treated and managed independently.[157] In fact, the water and energy sectors have coexisted harmoniously,[158] and were managed separately.[159] Such harmonious coexistence may also be ascribed to the fact that the demand from the industrial and public sectors were much lower than the current

154 See part two of chapter two above.
155 Hassan *Water history for our times* 5,6,14,15.
156 Thompson *Water law: a practical approach to resource management & the provision of services* 50.
157 Hamiche and Stambouli 2015 *Renewable and sustainable energy reviews* 319.
158 Thompson *Water law: a practical approach to resource management & the provision of services* 50.
159 Li *Understanding the water-energy nexus: A case study of Ningxia* iv. Wang *Water-energy nexus: A critical review paper* 2.

demand.[160] As a result, the water sector and energy sectors did not compete. In due course, however, this 'homeostasis' has changed due to climate change, urbanisation, economic growth, droughts and increased energy demands.[161]

In the past, energy production and resource extraction have received priority over water regulations, with the consequence that energy production had unlimited access to water.[162] However, as sustainable water principles have become more prominent across the globe, the protection of water resources surfaced.[163] As researchers attempted to avoid climate disruptions, the interlinkages between water and energy production became prevalent.[164]

Among the first studies to unravel the emerging links between water and energy was an analysis conducted by Gleick.[165] The analysis was done in a time in history when the bottled water industry was growing rapidly. Gleick[166] highlighted the quantity of energy required to produce and use bottled water, thereby creating a link between water and energy. His work has highlighted the interdependence of water and energy by analysing the required energy footprint in the production and use of bottled water.[167] Gleick continued to explore the energy requirement for each major lifecycle stage of bottled water manufacturing.[168] His paper has indicated that each lifecycle stage of the bottled water production required energy in some way or form, and that the production of bottled water required 2000 times the energy cost of producing tap water.[169] Gleick's study is particularly relevant for purposes of this study, as it has effectively confirmed the water-energy nexus by stating that the production of bottled

160 Thompson *Water law: a practical approach to resource management & the provision of services* 50.
161 Hardy 2012 *IJWRD* 152. Arroyo 2010 https://www.circleofblue.org/wp-content/uploads/2010/08/Arroyo-2010-Water-Energy-Nexus.pdf. Hamiche and Stambouli 2015 *Renewable and sustainable energy reviews* 320. Wang *Water-energy nexus: A critical review paper* 1.
162 Godden "The water-energy nexus" 74.
163 Godden "The water-energy nexus" 74.
164 Godden "The water-energy nexus" 75.
165 Gleick 2009 *Environ. Res. Lett*. 1.
166 Gleick 2009 *Environ. Res. Lett*. 1. Wang *Water-energy nexus: A critical review paper* 1.
167 Gleick 2009 *Environ. Res. Lett*. 1.
168 Gleick 2009 *Environ. Res. Lett*. 2.
169 Gleick 2009 *Environ. Res. Lett*. 6.

water requires a significant energy input.[170] This has since been labelled the concept of 'water for energy' and 'energy for water'. Other examples illustrating 'water for energy' or 'energy for water' include coal fired power generation (energy) which uses steam (as a form of water) to generate electricity, and energy consumption needed to pump water for consumption or even treating wastewater.[171] Gleick, however, did not explore the nature of the nexus between water and energy, he has only argued that such a nexus does indeed exist.

Since Gleick's analysis, various scholars have engaged in a systematic understanding of the relationship and interconnectedness between water and energy.[172] Scholarship in this regard is particularly useful in understanding why an integrated understanding of water and energy is a necessity for sustainable practises in the context of coal fired power stations.

### *3.3 The water-energy nexus*

In taking the discussion further, this section considers and explores the suggested integrated understanding between water and energy, or the so-called water-energy nexus.[173] The discussion moves away from 'silo' thinking to cross-sectoral resource management.[174] This is of particular importance for this study, as the water-energy nexus can then be understood as a process that links the actions of different sectors for achieving a more sustainable way of resource consumption.[175] Resource coupling refers to the interdependence of water and energy at the operational point of use as

170 Gleick recognised that bottled water goes through three phases: production, transportation, and use. Gleick 2009 *Environ. Res. Lett.* 2.
171 Endo, Tsurita, Burnett and Orencio 2017 *Journal of Hydrology: Regional Studies* 23.
172 Wang *Water-energy nexus: A critical review paper* 1. Hellegers 2008 *Water Policy* 1,2. Bhaduri 2015 *Water International* 724.
173 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15.
174 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15.
175 Harwood 2018 *Environmental Science and policy* 79.

well as at regional levels of natural resource availability. This includes surface and groundwater.[176]

The water-energy nexus is a cross-sectoral approach that presents itself as being polycentric and considering other sectors (like the energy sector) on equal terms.[177] This nexus approach promotes and provides for collaboration of policies so as to address complex issues in a sustainable manner.[178] As mentioned earlier, the water-energy nexus is three dimensional in nature and can be used as an analytical tool, a conceptual framework, or a scholarly discourse.[179]

It follows that the nexus effectively functions as a framework for integrated resource management.[180] Nevertheless, apart therefrom, the water-energy nexus serves multiple other purposes. Another purpose is that the nexus often offers guidance as to understanding the efficiency and measures to limit the demand for both water and energy. In this regard, the water-energy nexus may be understood and applied as an analytical tool.

### 3.3.1 The water-energy nexus as an analytical tool

Water and energy are vital goods that require monitoring, management and control in an analytical way. When doing something analytically, it involves the use of logical reasoning to reach a conclusion.[181] As an analytical tool, the water-energy nexus may be interpreted or understood as a decision support tool that assesses the water and energy sectors together in a holistic manner, enabling the quantification of cross-sectoral interlinkages and visualisation of existing imbalances.[182] It enables the user

176 De Bod *The South African water management framework: Lethabo power station as a case study* 19.
177 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15.
178 Fürst, Luque and Geneletti 2017 *International Journal of Biodiversity Science, ecosystem services & management* 412.
179 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15.
180 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15.
181 Collins dictionary 2021 https://www.collinsdictionary.com/dictionary/english/analytical.
182 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15.

to report on acquired results and to make interpretations thereof. The water-energy nexus as an analytical tool, aids in creating sustainability indicators[183] that can be used to track the status of resource use and availability at any given time.[184] This method of resource tracking can indicate how and where water consumption can be decreased in the energy sector.

### 3.3.2 The water-energy nexus as a conceptual framework

In the previous section the water-energy nexus was introduced as an analytical tool, it can also be used as a conceptual framework. A conceptual framework can be described as a network of connected concepts that provide for a detailed and complete understanding of an occurrence or phenomenon.[185]

As a conceptual framework, the water-energy nexus simplifies an understanding of water and energy linkages to enhance sustainable development.[186] The nexus approach provides an integrated framework that can be used to unpack the intricate interconnections and interdependencies between the water and energy sectors.[187] The water-energy nexus as a conceptual framework can be used to examine how water and energy processes interact, in an attempt to build models and matrices that inform policy makers.[188] Therefore, to illustrate the usefulness of the water-energy nexus as a conceptual framework, it may typically be utilised by coal fired power stations to inform decision makers of the volume of water required to generate a certain amount of electricity. The volume of water required can then be decreased in the future when this information is used to improve technology.

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183 'Sustainability indicators' cede information on the performance and current status of resources at a given spatial scale, and for quantifying the state or trend of resource utilisation. These indicators can be defined as 'simplified decision support tools that aim to enhance the understanding of complex interrelationships among resource, converting those relationships into simple formulations that make assessments easier'. Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15,16.

184 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15,16.

185 Jabareen 2009 *International Journal of Qualitative Methods* 51.

186 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15.

187 Itayi, Mohan and Saito 2021 *Environ. Res. Lett.* 1.

188 Itayi, Mohan and Saito 2021 *Environ. Res. Lett.* 2.

### 3.3.3 The water-energy nexus as a discourse

A discourse typically refers to a formal extended expression of knowledge on a subject.[189] It follows that, as a discourse, the water-energy nexus approach can be used for problem framing and cross-sectoral collaboration.[190] This can occur when the energy sector informs the water sector of its water needs and the water sector replies with its water constraints. The concept encourages knowledge integration via collaborative decision-making across various fields of study and management.[191] When using the water-energy nexus as a discourse, it can enhance the sharing of knowledge relating to the water and energy sectors. This sharing of information can aid in finding methods to reduce water consumption at coal fired power stations.

## *3.4 Advantages and opportunities of the water-energy nexus approach*

When following a nexus approach, and by embracing the multiple purposes of the nexus canvassed above, certain areas of opportunity for sustainably improving water and energy security emerge. These opportunities include increasing resource productivity by applying the water-energy nexus as an analytical tool; stimulating development through economic incentives by applying the water-energy nexus as an academic discourse; and coherence between governance, institutions and policy when applying the water-energy nexus as conceptual framework.[192] The current lack of coordination in water and energy planning can be aided with the nexus approach.[193] Only with a nexus approach is it possible to take full advantage of the opportunities to increase energy efficiency in the water sector; to exploit the possibilities of the water system as a source of flexibility for the power system; to extract more energy from water; and to reduce the water footprint of the energy industries.

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189 Merriam Webster 2021 https://www.merriam-webster.com/dictionary/discourse.

190 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 15.

191 Wiegleb and Bruns 2018 *Front. Environ. Sci.* 2.

192 Stockholm Environment Institute "Opportunities for improving water, energy and food security through a nexus approach" 36.

193 Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 1.

The water-energy nexus, with its integrated resource management approach, provides for effective adaptation to climate change.[194] One such example being the conservation of energy as an approach to save water, inevitably adapting to climate change.[195] When applying the water-energy nexus approach as an analytical tool, conceptual framework, or discourse, it enables resource management and environmental issues to be discussed in the presence of policymakers and stakeholders alike, bridging the gap in knowledge between policymakers and environmental practitioners.[196] The nexus approach can therefore also be used as a policy making tool. When applying the water-energy nexus as an analytical tool, it can adequately capture the different synergies between the water and energy sectors while reducing the trade-offs present in the interactions between them.[197] The need for integrated planning and system thinking has surpassed the need to optimise one resource over another.[198] Policymakers should focus on achieving specific targets that are cross-sectoral and fit the local circumstances of South Africa,[199] while keeping in mind that water is not merely a national commodity but crosses political boundaries.[200]

## *3.5 Concluding remarks*

The water-energy nexus is a complex concept coupled at multiple scales, without a formal definition.[201] This chapter briefly explored the history of the water-energy nexus, drawing from some of the first scholars on the subject. The main aim of the chapter revolves around the definition of the water-energy nexus and how the water-

194 Rasul and Sharma 2015 *Climate policy* 682. Wang *Water-energy nexus: A critical review paper* 3.
195 Wang *Water-energy nexus: A critical review paper* 3.
196 Mabhaudhi, Simpson, Badenhorst, Mohammed, Motongera, Senzanje and Jewitt *Assessing the state of the water-energy-food (WEF) nexus in South Africa* 27.
197 Itayi, Mohan and Saito 2021 *Environ. Res. Lett.* 2.
198 When considering the three dimensional nexus in South Africa, applying the water-energy nexus as a conceptual framework might yield the most success. The lack of coordination in water and energy planning as well as the issue of coherence between governance, institutions and policy, can be overcome when applying the water-energy nexus as a conceptual framework. Shannak, Mabrey and Vittorio 2018 *Water-Energy Nexus* 18. Boas, Biermann and Kanie 2016 *Int. Environ. Agreements.*
199 Boas, Biermann and Kanie 2016 *Int. Environ. Agreements.*
200 Boas, Biermann and Kanie 2016 *Int. Environ. Agreements.*
201 Scott 2011*Energy Policy* 6622, 6623.

energy nexus can be used as either an analytical tool, a conceptual framework, or for discourse.

The water and energy sectors are highly developed within themselves, but limited efforts are made to manage and account for the many links between them. Currently, there is little to no coordination between the water and energy sectors.[202] A nexus approach can be beneficial because it removes the institutional silos in governance and policy circles.[203] The analysis has determined that the water-energy nexus can enhance water allocation and management at state owned coal power stations when applying one of its multiple purposes.

Using the nexus and its different applications as explored in chapter 3, chapter 4 assesses how the water-energy nexus may be utilised and implemented to govern water resources more sustainably at coal fired power stations.

202 See 3.4 above. Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi 2020 *Environmental Science and Policy* 1.
203 Belinskij 2015 *Water* 5396-5398.

# Chapter 4

## *Existing nexuses: Towards sustainable water use practices*

### *4.1 Introduction*

Chapter 3 above argued that the use and governance of energy and water resources need to be addressed simultaneously through the water-energy nexus approach. In fact, the preceding chapter has provided a number of ways in which the said nexus can be applied to enhance sustainability, especially in the context of water use during energy generation.

The reality is, however, that water in South Africa is still being regulated by means of so called "sectoral Acts".[204] This approach (which seems contrary to the water-energy nexus approach) may potentially not only contribute to regulatory fragmentation, but may ultimately result in excessive water use practises at coal fired power stations, as water and energy are regulated independently. In an attempt to curb excessive water use during energy generation, this chapter reviews the existing legal framework, and determines if the South African framework provides for, or allows the water-energy nexus to be utilised and implemented to govern water resources more sustainably at coal fired power stations. This chapter is structured as follows: part one provides a brief overview of the current legislation pertaining to coal energy in South Africa and examines whether the energy legislator has included nexus thinking in the energy framework. Part two builds on the theory set out in chapter two, and considers, from a legal perspective, nexus thinking in the water regulatory framework. The aim of these parts are to determine whether more sustainable water use practises at coal fired power stations can be prioritised by making use of the law. Part three is structured along the lines of the stated aim and moves beyond the theoretical understanding of the water-energy nexus and sets to establish a secure and

204 Chapter 2 deals with the water regulatory framework, while chapter 4.2 deals with the energy regulatory framework.

sustainable future for water use at coal fired power stations by examining 'nexus thinking' in the regulatory framework.

## *4.2 Brief reflections on the regulatory framework at South Africa's coal fired power stations: Silo or nexus thinking?*

When the energy sector is observed, a set of sector specific laws and policies are relevant. These include, but are not limited to: The *Electricity Act* 41 of 1987; *White Paper on the Energy Policy of the Republic of South Africa* of 1998; *National Energy Regulator Act* 40 of 2004; *National Energy Bill*; the *Electricity Regulation Act* 4 of 2006 and South Africa's Integrated Resource Plan (IRP).[205] Each of these regulatory measures will be introduced briefly to unravel the potential of 'nexus thinking' in the existing water and energy legal framework(s).

### 4.2.1 The Electricity Act 41 of 1987

The long title of the *Electricity Act* provides for the the continued existence of the Electricity Control Board and for control of the generation and supply of electricity; and for matters connected therewith. The long title also articulates the purpose of the Act, which includes the "control of the generation and supply of electricity".[206] The Electricity Control Board is set to ensure order in the generation and efficient supply of electricity.[207] The Act requires a licence for the undertaking of any electricity generation or the supply thereof.[208] Such a licence may be acquired by way of application to the Electricity Control Board.[209] Notably, this Act requires a licensee to apply for permission if he / she plans to use, in any catchment area, water from a public stream for: the generation of steam or electricity; condensing; cooling; or incidental purposes.[210] This requirement serves to illustrate 'nexus thinking' within the energy sector, because such permission may then be granted subject to certain

205 Gen Not 1360 in GG 42784 of 18 October 2019.
206 Preamble to the *Electricity Act* 41 of 1987.
207 S3 of the *Electricity Act* 41 of 1987.
208 S6 of the *Electricity Act* 41 of 1987.
209 S7(1) of the *Electricity Act* 41 of 1987.
210 S18(1) of the *Electricity Act* 41 of 1987.

conditions for the purpose of preventing or controlling pollution of the water in a public stream.[211] In this way, the generation of electricity takes note, and refers to water governance issues. Eskom, however, does not require a licence to generate electricity under the *Electricity Act*.[212] As a result, this Act does not necessarily add to the discourse to reduce excessive water use practises at Eskom's coal fired power stations.

### 4.2.2 White Paper on the Energy Policy of the Republic of South Africa of 1998

The South African government recognised the need to integrate the different energy policy processes as well as the need for policy stability, and hence the *White Paper on the Energy Policy of South Africa,* 1998[213] was drafted. The *White Paper on the Energy Policy of the Republic of South Africa*, hereafter referred to as the *White Paper on the Energy Policy*, is an overarching policy document representing South Africa's overall energy needs and options. The purpose of the *White Paper on the Energy Policy* is to clarify government policy regarding the supply and consumption of energy.[214] The policy was developed to strengthen existing energy systems, to develop underdeveloped systems and to bring about change in the energy sector.[215] The *White Paper on the Energy Policy* is of specific relevance for this study, as it was the first regulatory attempt at a holistic approach to energy law. The paper attempts to make the government's approach more transparent and to clarify organisational roles. The effective communication of the policy as well as integration of the policy processes is a clear indication of 'nexus thinking' in the energy sector. The *White Paper on the Energy Policy* identifies that causal linkages extend beyond the energy sector and requires energy policies to be coordinated with other sectors (like water). It does this by identifying cross-cutting issues in the energy sector. The *White Paper on the Energy Policy* has addressed these issues by the establishment of *Integrated Energy Planning*

211 S18(2) of the *Electricity Act* 41 of 1987.
212 S6(e) of the *Electricity Act* 41 of 1987.
213 *White Paper on the Energy Policy of the Republic of South Africa* of 1998.
214 Preamble to the *White Paper on the Energy Policy of the Republic of South Africa* of 1998.
215 Preamble to the *White Paper on the Energy Policy of the Republic of South Africa* of 1998.

(IEP);[216] providing statistics and information on energy to the public to support *IEP*;[217] creating energy efficiency improvements by establishing energy efficiency norms and standards;[218] creating an energy-environment policy that minimise the environmental impacts of the energy sector;[219] improving research and development, human resource development, international energy trade and cooperation, the alignment of fiscal and energy policies and the creation of mechanisms to improve communication with the different spheres of government. The *White Paper on the Energy Policy* acknowledges that sectoral policies should take notice of linkages and overlaps in policy developments of other sectors.[220] The paper has established policy objectives for the energy sector. Some of the important objectives include the improvement of energy governance, and the management of energy-related environmental impacts. These objectives can be reached by improving the energy policy formulation process and by following a no-regrets approach on energy-environment decisions.[221]

### 4.2.3 National Energy Regulator Act 40 of 2004

The National Energy Regulator of South Africa (NERSA),[222] was established in terms of the *National Energy Regulator Act* 40 of 2004.[223] The Act was set to establish a single regulator to regulate South Africa's three energy industries; electricity, petroleum and piped gas.[224] The *Electricity Regulation Act* [225] functions to establish a

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216 IEP is a process with technical functions like interpreting the requirements of national economic, social and environmental policies for the energy sector. *Preamble to the White Paper on the Energy Policy of the Republic of South Africa* of 1998.

217 Preamble to the *White Paper on the Energy Policy of the Republic of South Africa* of 1998.

218 Preamble to the *White Paper on the Energy Policy of the Republic of South Africa* of 1998.

219 Preamble to the *White Paper on the Energy Policy of the Republic of South Africa* of 1998.

220 *White Paper on the Energy Policy of the Republic of South Africa* of 1998.

221 Objective 2 and 4 of the *White Paper on the Energy Policy of the Republic of South Africa* of 1998.

222 *NERSA* has many functions, including the issuing of licences and setting tariffs. Department of Energy 2021 http://www.energy.gov.za/files/esources/electricity/electricity_nersa.html#:~:text=NERSA%2C%20established%20in%20terms%20of,title%20to%20gas%20and%20petroleum.&text=It%20is%20also%20expected%20to,participation%20in%20the%20energy%20sector.

223 *National Energy Regulator Act* 40 of 2004.

224 Department of Energy 2021 http://www.energy.gov.za/files/esources/electricity/electricity_nersa.html#:~:text=NERSA%2C%20established%20in%20terms%20of,title%20to%20gas%20and%20petroleum.&text=It%20is%20also%20expected%20to,participation%20in%20the%20energy%20sector.

225 *Electricity Regulation Act* 4 of 2006.

national regulatory framework for the electricity supply industry and to provide for licences. Every decision of the Energy Regulator must be in writing, in line with the *Constitution*, in the public interest and within the powers of the Energy Regulator. These decisions must be procedurally fair and based on reasons, facts and evidence.[226]

### 4.2.4 National Energy Bill

The *National Energy Bill*[227] is a draft Bill with the purpose of ensuring that diverse energy resources are made available to South Africans in a sustainable[228] and affordable way. Additionally, it supports economic growth, it accounts for environmental management requirements, international obligations, and it promotes efficient energy generation and consumption.[229] If the Bill is enacted, it can function as the central regulatory statute for the energy sector in South Africa.[230] Additionally, the Bill will give effect to the *White Paper on the Energy Policy*.[231] The Bill requires that the minister must develop an *IEP* that deals with issues relating to the supply, transformation, transport, storage and demand of energy in a way that accounts for, among others, the availability of resources, the environment and international commitments.[232] Chapter 4 of the *National Energy Bill* requires that the *IEP* must take account of water,[233] sustainable development[234] and environmental impacts.[235] These requirements are yet another example of existing tools in legislation than can be used and adapted to apply the water-energy nexus approach in the energy sector.

### 4.2.5 Electricity Regulation Act 4 of 2006

The *Electricity Regulation Act* 4 of 2006 was created to establish a national regulatory framework for the supply of electricity as well as to make the National Energy

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226 S10(1)(a)-(f) of the *National Energy Regulator Act* 40 of 2004.
227 Gen Not 710 in GG 31124 of 3 June 2008.
228 Item 1 of Gen Not 710 in GG 31124 of 3 June 2008.
229 Item 2 of Gen Not 710 in GG 31124 of 3 June 2008.
230 Glazewski *The Legal Framework for Renewable Energy in South Africa* 9.
231 *White Paper on the Energy Policy of the Republic of South Africa* of 1998.
232 S16(1)&(2) of the *Electricity Regulation Act* 4 of 2007.
233 S16(3)(b) of Gen Not 710 in GG 31124 of 3 June 2008.
234 S16(4)(a) of Gen Not 710 in GG 31124 of 3 June 2008.
235 S16(4)(e) of Gen Not 710 in GG 31124 of 3 June 2008.

Regulator the custodian of the electricity regulatory framework and to provide for licences to generate electricity.[236] The objectives of the Act are to achieve efficient and sustainable development and operation of electricity supply infrastructure in South Africa to its present and future customers and to achieve the effective long-term sustainable supply of electricity.[237] The Act is however, not clear on how it intends to achieve this. The Act promotes the use of diverse energy sources and energy efficiency, but is yet again not clear on how it intends to do so.[238] The Act requires that the regulator issue rules, designed to implement the national government's electricity policy framework, and the integrated resource plan.[239] It further requires the establishment and management of monitoring and information systems, and the coordination of the integration thereof with other relevant information systems.[240]

### 4.2.6 South Africa's Integrated Resource Plan

In 2009 the then Minister of Mineral Resources and Energy published the Integrated Resource Plan (IRP).[241]

> The *IRP* is an electricity infrastructure development plan based on least-cost electricity supply and demand balance, taking into account security of supply and the environment (minimize negative emissions and water usage).[242]

The *IRP* has incorporated the objective of reduced water consumption.[243] The *IRP* is in line with South Africa's goals to diversify its energy mix, reducing the heavy reliance on coal as its primary energy source.[244] However, the *IRP* recognises that coal will continue to dominate electricity generation in the country for the foreseeable future, but requires that new investments be made in more efficient coal technologies.[245] The *IRP* mentions a water-energy nexus and requires that consideration should be given

236 *Electricity Regulation Act* 4 of 2007.
237 S2(a) of the *Electricity Regulation Act* 4 of 2007.
238 *Electricity Regulation Act* 4 of 2007.
239 S4(a)(iv) and (v) of the *Electricity Regulation Act* 4 of 2007.
240 S4(a)(iv) and (v) of the *Electricity Regulation Act* 4 of 2007.
241 Gen Not 1360 in GG 42784 of 18 October 2019.
242 Gen Not 1360 in GG 42784 of 18 October 2019 8.
243 Gen Not 1360 in GG 42784 of 18 October 2019 8.
244 Gen Not 1360 in GG 42784 of 18 October 2019 11.
245 Gen Not 1360 in GG 42784 of 18 October 2019 12.

to energy technologies that use less water to generate electricity.[246] Unfortunately, the policy is silent on how Eskom will be reliably supplied with its water needs and provides no real solutions on how water management at the operational level will be improved.[247]

### 4.2.7 Preliminary remarks

The South African legal framework for energy, as set out above, consists of an array of legislation and policy documents, each dealing with specific matters.[248] The question however arises whether the energy and water sectors' legal frameworks are aligned or at least affiliated.[249] Regrettably, this does not seem to be the case. There are operational interdependencies between water and energy and a silo approach, such as that of South Africa's energy and water sectors, which may be detrimental because it operates in isolation from one another, ignoring constraints on water resources and availability thereof. The lack of a systematic approach, policy integration and coordinated planning on coal fired power stations further impede the effective management of water and energy.[250] The water and energy sectors require cross-innovation in existing legal systems. Effective governance at multiple scales can only occur if the legal response to these issues move beyond the existing water and energy 'silos'.[251]

In addition to this 'silo approach', institutional fragmentation remains a reality. Institutional fragmentation takes place on either a vertical or horizontal level. Vertical fragmentation refers to non-alignment of government practices while horizontal fragmentations pertain to the activities of different government departments.[252] The South African energy legal framework is fragmented on the horizontal level due to

246 Item 2.5 in Gen Not 1360 in GG 42784 of 18 October 2019.
247 Mathetsa, Simatele, Rampedi and Gericke *Journal of Energy in Southern Africa* 16.
248 These matters include among others: pricing and licensing; procurement; mitigation; the establishment of a national energy regulator; and fiscal aspects. Mauger and Barnard 2018 *J. energy South. Afr.* 3.
249 Mauger and Barnard 2018 *J. energy South. Afr.* 3.
250 Mathetsa, Simatele, Rampedi, and Gericke *Journal of Energy in Southern Africa* 12.
251 Godden "The water-energy nexus" 73.
252 Kotzé 2006 *PER* 77. Mauger and Barnard 2018 *J. energy South. Afr.* 3.

energy laws being drafted with certain energy sources as its main motivation.[253] These energy sources include coal, gas, and petroleum.[254] The horizontal level of regulation of energy in the country, relates to different energy sources as well as different fields of law, contributing to the fragmentation issue.[255] This dissertation posits that the lack of a systematic approach, policy integration and coordinated planning between the water and energy sectors, obstruct the effective and sustainable management of water and energy.[256]

Administrative boundaries can cause major issues in resource management. Resources are managed at national level and set out in policy documents, production and consumption requirements then trickle down to local government without concern for local consequences and environmental impacts.[257] To illustrate, the use of coal in power generation has many serious impacts on the environment and local communities, one such impact being water pollution.[258] Local authorities have little say over resource management and environmental impacts of decision-makers. Water use and development are prescribed at national level,[259] with little to no regard for the resource restrictions of local communities. Regulatory cooperation at national level can aid local government challenges with resource management.[260]

When water and energy are considered together, a broader set of institutional relationships come to the fore. The nexus should be considered in broader terms, moving beyond the input-output approach. To achieve this, two concepts were developed and applied, namely the resource coupling concept and multi-tiered arrangement concept.[261] Resource coupling arise at different spatial scales but is

253 South Africa is most reliant on coal to produce its energy needs. When energy laws are drafted, coal fired power plants are mostly at the centre of considerations. Du Plessis 2015 *SAJS* 1,2. Mauger and Barnard 2018 *J. energy South. Afr.* 4. See section 4.2 above.
254 Du Plessis 2015 *SAJS* 1,2. Mauger and Barnard 2018 *J. energy South. Afr.* 4.
255 Mauger and Barnard 2018 *J. energy South. Afr.* 4.
256 Mathetsa, Simatele, Rampedi, and Gericke *Journal of Energy in Southern Africa* 12.
257 De Bod *The South African water management framework: Lethabo power station as a case study* 19. Scott 2011 *Energy Policy* 6623.
258 Munawer 2018 *Journal of sustainable mining* 87,88.
259 Water management is governed by parliament in South Africa. Department of Water Affairs *NWRS2*.
260 Scott 2011*Energy Policy* 6623.
261 Scott 2011*Energy Policy* 6623.

qualitatively different from the multi-tiered nature of institutions. Energy development is overseen by national government in the form of legislation and policies, leading to the justifiable, but problematic situation where local resources are not managed by local authorities.

A study has presented three cases that illustrated the interaction between water-energy coupling and tiered institutions. The first case highlighted the disconnection between local and regional management of water and energy: The large-scale infrastructure produces most of the water and energy requirements of the state of Arizona. This leaves little room for local renewable energy to be developed in the area.[262] In the second case it is noted that coal is used to generate about half of the United States' electricity, and that this leads to acid mine drainage contaminating water sources.[263] In South Africa this figure is closer to 62%,[264] with acid mine drainage being a huge issue in the country, due to large-scale mining activity.[265] This case is illustrative of the issues with multi-tiered institutions, being mining companies and local government. Policy documents and regulations relating to water use and environmental harm can hardly be effective if it is widely accepted that environmental degradation can be off-set by employment opportunities and economic growth.[266] The third case involves the gas-water quality nexus, weighing economic gain by landowners against the local water quality in the north-eastern area of the United States. A similar debate has occurred in South Africa regarding fracking in the Karoo being economic gain versus the environmental impact.[267] The purpose of these cases is to show the incongruity between water-energy coupling and institutional decision-making.[268]

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262 Scott 2011 *Energy Policy* 6624.
263 Scott 2011 *Energy Policy* 6625.
264 Department of Mineral Resources and Energy 2020 http://www.energy.gov.za/files/coal_frame.html#:~:text=South%20Africa's%20indigenous%20energy%20resource,needs%20are%20provided%20by%20coal.
265 McCarthy 2011 *S Afr J of Sci* 1.
266 Scott 2011 *Energy Policy* 6626.
267 Fullerton 2018 https://www.senseandsustainability.net/2018/08/28/south-african-government-supports-fracking-in-the-karoo/.
268 Scott 2011 *Energy Policy* 6628.

Although the regulatory framework, as canvassed above, remains silo based and generally fragmented, and although the legal framework does not explicitly recognise the notion of a water-energy nexus, instances were however identified that depict nexus thinking. These were: the requirement of licenses for certain water use practises for the purpose of preventing or controlling water pollution;[269] effective communication of policy documents and the integration of policy processes;[270] decisions taken by the energy sector to be in writing, in the public interest and in line with the *Constitution*;[271] the requirement that *IEP* account for water, sustainable development and environmental impacts;[272] the requirement that an integrated resource plan be implemented;[273] and that such resource plan incorporate as one of its objectives, reduced water consumption.[274] It is argued that these glimpses of nexus thinking contain special opportunities for resource integration from a governance perspective.

### *4.3 Nexus thinking towards more sustainable water use practices*

As discussed in chapter 2, South Africa's water sector is governed by the following laws and policies: the *Constitution*,[275] *NEMA*,[276] the *NWA*,[277] the *WSA*,[278] and the *NWRS* 1[279] and 2.[280] From the discussion, it came to the fore that integrated legislation or an integrated approach to manage different sectors, is not a new concept, and has been implemented in South Africa in the past. *Integrated Water Resource Management* (IWRM), as introduced in chapter 2.3.2.3 above, was one of the first approaches to suggest integrated thinking of resource management.[281] The purpose

269 S18(2) of the *Electricity Act* 41 of 1987.
270 *White Paper on the Energy Policy of the Republic of South Africa* 1998.
271 S10(1)(a)-(f) of the *National Energy Regulator Act* 40 of 2004.
272 S16(3)(b), (4)(a) and (4)(e) of Gen Not 710 in GG 31124 of 3 June 2008.
273 S4(a)(iv) and (v) of the *Electricity Regulation Act* 4 of 2007.
274 Gen Not 1360 in GG 42784 of 18 October 2019 8.
275 *The Constitution of the Republic of South Africa*, 1996.
276 *The National Environmental Management Act* 107 of 1998.
277 The *National Water Act* 36 of 1998.
278 The *Water Services Act* 108 of 1997.
279 Department Water Affairs & forestry *NWRS* i.
280 Preamble to Part 1 of Chapter 2 of the *NWA* 36 of 1998.
281 United Nations "Report of the World Summit on Sustainable Development" 1-166.

of *IWRM* is to regulate the environment, enable policy and provide management instruments for water resources.[282] *NEMA* endorses *IWRM* as one of its objectives.[283]

The notion of *IWRM* is valuable, especially when certain legal tools pertaining to water are concerned. Although the contemporary water and energy challenges, which amount to water and load shedding respectively, are not adequately addressed by IWRM alone,[284] the water-energy nexus framework contains innovative elements, like holistically integrating different policy documents that could be complementary to *IWRM*.[285] Instead of focusing on one sector (water), the approach should rather be implemented in such a way that it is polycentric in nature and inclusive of other sectors (energy).[286] The *IWRM* provides for legal tools that may in fact govern the impacts of energy generation on water. Such measures include environmental impact assessment laws to protect water sources.

*IWRM* is defined as a process that coordinates management of water and related resources in a way that extracts the maximum economic and social benefit without compromising the integrity and sustainability of ecosystems.[287] *IWRM* is based on three pillars, environmental sustainability, economic efficiency and social equity.[288] The *IWRM* approach applies knowledge from different disciplines and involves relevant stakeholders in management and decision-making to implement sustainable solutions for water issues. It is a flexible process and a comprehensive planning tool for water resource management. The *IWRM* approach is a useful tool to structure and manage water holistically and sustainably.[289] The water-energy nexus, as described in chapter three, is the relationship between water requirements for energy production and

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282 Claassen 2013 *International Journal of Water Governance* 323.
283 *NEMA* 107 of 1998.
284 Mathetsa, Simatele, Rampedi and Gericke *Journal of Energy in Southern Africa* 16. Biswas *International Journal of Water Resource Development* 12,13. Molobela and Sinha 2011 *Afr. J. Environ. Sci. Technol.* 993. Madigele, Snowbal and Fraser 2015 *International Journal of Water Governance* 8. Claassen 2013 *International Journal of Water Governance* 334.
285 Simpson and Jewitt 2019 *Front. Environ. Sci.* 3.
286 Simpson and Jewitt 2019 *Front. Environ. Sci.* 3.
287 The International Water Association *Integrated Water Resource Management: Basic Concepts* 1.
288 The International Water Association *Integrated Water Resource Management: Basic Concepts* 1.
289 Mathetsa, Simatele, Rampedi and Gericke 2019 *Journal of Energy in Southern Africa* 16.

transmission and the energy requirements for water collection, purification and transport.[290] The water-energy nexus identifies the need to consider both water and energy in decision-making and management.[291] The nexus is essentially a process that links the actions of the water and energy sectors to achieving a more sustainable way of resource management and consumption.[292]

When comparing the *IWRM* approach with the nexus approach it becomes clear that both approaches are closely related. Both approaches inevitably aim for sustainable resource use.[293] The two approaches have similar views on segmented sectoral policies and decision-making and contends that such segregated planning leads to unsustainable resource use. *IWRM* and the nexus approach emphasise the need for coordination between different sectors (like water and energy).[294] Both *IWRM* and the nexus approach can be described as 'tools' for the identification of solutions to complex water issues across various interacting sectors.[295] The difference between the two is that *IWRM* can be described as a management process while the nexus approach is a systems tool to characterise issues.[296]

South Africa requires an approach where water-related challenges and energy issues are simultaneously and equally addressed.[297] The water-energy nexus components are governed in segregation; scholars suggest that the *IWRM* approach can mitigate this segregation through its ability to promote a multi-participatory approach in resource governance.[298]

290 Aster *What is the water-energy nexus?* 1.
291 Villamayor-Thomas "The water-energy nexus in Europe and Spain" 105.
292 Harwood 2018 *Environmental Science and policy* 79.
293 UNSGAB *Nexus concept // The nexus approach v IWRM – Gaining conceptual clarity* 1.
294 UNSGAB *Nexus concept // The nexus approach v IWRM – Gaining conceptual clarity* 2.
295 Grigg 2019 *Journal of contemporary water research & education* 24.
296 Grigg 2019 *Journal of contemporary water research & education* 24.
297 Mathetsa, Simatele, Rampedi and Gericke 2019 *Journal of Energy in Southern Africa* 16.
298 Mathetsa, Simatele, Rampedi and Gericke 2019 *Journal of Energy in Southern Africa* 16.

## *4.4 Linking the water-energy nexus with the Sustainable Development Goals (SDGs)*

Throughout, reference is made to 'sustainability' and 'sustainable development'. Sustainable development can be defined as:

> the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations.[299]

The concept of sustainability lies at the heart of the water-energy nexus approach and resource management in South Africa. Three of the Sustainable Development Goals (SDGs) are dedicated to nexus problems. These are food security, sustainable management of water[300] and affordable and clean energy.[301] For the purpose of this dissertation, only goal six and seven will be relevant. Goal six strives to ensure availability and sustainable management of water and sanitation for all, and goal seven strives to ensure access to affordable, reliable, sustainable and modern energy for all. Other aspects related to water and energy are cross-cutting issues meaning that improving sustainability in the water-energy nexus can have a positive effect on other sustainable development goals.[302]

Internationally, human rights norms, and Sustainable Development Goals are influential in establishing interconnections between the rights to water and energy.[303] The water-energy nexus approach strives to manage resources in a way that ensures the sustainability of the resource over time.

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299 S1 of *NEMA* 107 of 1998.

300 Goal six of the Sustainable Development Goals is sustainable management of water. United Nations *Sustainable Development Goals* 6.

301 Goal seven of the Sustainable Development Goals is affordable and clean energy. United Nations *Sustainable Development Goals* 6.

302 Saladini, Betti, Ferragina, Bouraoui, Cupertino, Canitano, Gigliotti, Autino, Pulselli, Riccaboni, Bidoglio and Bastianoni *Ecological Indicators* 690. United Nations *Sustainable Development Goals* 1-17.

303 Internationally, UN General Comment No 15 outlines the right to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use. A2 of the CESCR General Comment No 15 *The right to water* 1.

## *4.5 Moving beyond the theoretical understanding of the water-energy nexus: "Nexus thinking" for a secure and sustainable future*

Concerns about water availability and load shedding should be influential in driving the evolution or development of the water-energy nexus in South Africa. This development is critical to ensure sustainable water use practises at South Africa's coal fired power stations. This section unravels, from a legal perspective, how the theoretical foundations of the water-energy nexus can be translated into practise.

### 4.5.1 Can 'nexus thinking' alleviate water and energy pressures?

With demand for the precious resources of water and energy only set to grow, a new approach must be put into action. The world population is growing by 80 million people per annum. Currently, it is estimated that by 2030 the global demand for water will increase with 30% and the demand for energy by 40%.[304] To illustrate that 'nexus thinking' can reduce water and energy pressures the following case study serves as example.

The Mpumalanga province in South Africa has an abundance of coal resources and is home to most of the country's coal fired power plants. Additionally, the province has many operational coal mines. Unfortunately, 46.4% of the county's high potential arable soil is located in Mpumalanga and mining activity is therefore reducing the area of arable soils for food production. This in turn, threatens food security, air quality and water availability in the country.[305]

'Nexus thinking' allows for externalities as mentioned above to be minimised or avoided by facilitating integrated planning that can address possible consequences of certain decisions. The nexus concept involves different stake-holders across the various water and energy sectors, and in this case study, the food sector as well.

304 Smedley *The Guardian* 1.
305 Simpson and Jewitt 2019 *Front. Environ. Sci.* 4.

### 4.5.2 Does the Water-Energy Nexus address resource security?

Resource security can be defined as the ability to secure access to a current level of resource demand, or a higher level of resource demand if the current level does not meet material needs.[306] Resource security is relevant in the context of water and energy as South Africa has faced "water shedding" in the past[307] as well as continuous "load shedding".[308] South Africa's water resource security has a number of challenges. These challenges include droughts, physical water scarcity, growing population and growing water demand, industrial and agricultural development, as well as infrastructure that causes water losses and water pollution.[309] Energy security in South Africa has deteriorated significantly. Some of the key sectors are in crisis, electricity shortages are commonplace and coal shortages and quality issues plague Eskom.[310]

Existing case law provides some guidance as to minimum core / resource security. South Africans have a right to water. These rights are contained in *The Human Right to Water and Sanitation*, [311] as well as in the *Constitution*.[312] In *Mazibuko and Others v City of Johannesburg and Others*[313] it was contested whether Johannesburg's policy in relation to free basic water supply, six (6) kilolitres of free water per month to every accountholder, is in conflict with section 27 of the *Constitution* or section 11 of the *Water Services Act*. The constitutional court has found that the free basic water policy was within reasonableness and not in conflict with the *Constitution* or the *Water Services Act*.[314] The court has confirmed that South African households are entitled to

306 Wackernazel, Hanscom, Jayasinghe, Lin, Murthy, Neill and Raven *Nature Sustainability* 731.
307 Alexander 2018 https://www.bloomberg.com/news/articles/2019-04-12/looking-back-on-cape-town-s-drought-and-day-zero#:~:text=Labelled%20%E2%80%9CDay%20Zero%E2%80%9D%20by%20local,water%20splashed%20across%20news%20sites.
308 Daniel 2021 https://www.businessinsider.co.za/eskom-load-shedding-worst-case-scenario-for-south-africa-2021-6#:~:text=The%20following%20month%2C%20South%20Africans,by%20Eskom's%20revised%20maintenance%20plans.&text=With%20a%20reduction%20in%20capacity,7%20billion. Robins 2019 *JSAS* 5. Businesstech 2021 https://businesstech.co.za/news/energy/541566/load-shedding-in-south-africa-is-inevitable-ramaphosa/.
309 Mutamba *Water and Society* 49.
310 Trollip, Butler, Burton, Caetano and Godhino *MAPS* 27.
311 *The Human Right to Water and Sanitation*, adopted 3 August 2010, UNGA Res A/RES/64/292.
312 S27(1)(b) of the *Constitution*, 1996.
313 *Mazibuko and Others v City of Johannesburg and Others* 2009 ZACC 28 para 6.
314 *Mazibuko and Others v City of Johannesburg and Others* 2009 ZACC 28 para 9.

free basic water consisting of at least 6 000 litres of water per month,[315] and that this amount was fair and reasonable.

South Africans are entitled to free basic electricity of 50kWh per household per month.[316] In *Joseph and other v City of Johannesburg* the dispute before the constitutional court was in respect of the termination of electricity supply following the non-payment by the landlord to City Power (Pty) Ltd.[317] The applicants have relied on the right to access to adequate housing[318] and the right to human dignity.[319] It was however, established in *Joseph and other v City of Johannesburg*[320] that there is no socio-economic or fundamental right to access to electricity.

The integrity of the environment must be maintained to sustainably achieve resource security and fulfil the basic human right to water, while access to resources like water and energy are simultaneously addressed and improved. The nexus approach must be implemented in such a way that it considers the livelihoods of people as well as the environment. However, to achieve sustainability, the protection of the environment has necessarily to be prioritised.[321] The combination of water and energy in a nexus framework for increased resource efficiency, is the best way to achieve the sustainable development goals as set out by the United Nations. The sustainable development goals only serve as basis for the water-energy nexus to be developed upon.[322]

315 South African Government 2021 https://www.gov.za/faq/government-services/how-do-i-access-free-basic-municipal-services. *Mazibuko and Others v City of Johannesburg and Others* 2009 ZACC 28.
316 South African Government 2021 https://www.gov.za/faq/government-services/how-do-i-access-free-basic-municipal-services. *Joseph and Others v City of Johannesburg and Others* 2010 4 SA 55 (CC) para 11.
317 *Joseph and Others v City of Johannesburg and Others* 2010 4 SA 55 (CC) para 1.
318 S26 of the *Constitution*, 1996.
319 S10 of the *Constitution*, 1996.
320 *Joseph and Others v City of Johannesburg and Others* 2010 4 SA 55 (CC) para 11.
321 Simpson and Jewitt 2019 *Front. Environ. Sci.* 5.
322 Simpson and Jewitt 2019 *Front. Environ. Sci.* 5.

### 4.5.3 Governance considerations associated with the water-energy nexus at coal fired power stations

The water-energy nexus requires the integration of the water and energy sectors for effective governance. This will have the outcome that the synergies between water availability and energy generation at coal fired power stations are enhanced while managing trade-offs and avoiding conflicts.[323]

The South African policies allow for a water-energy nexus approach to be implemented, but currently this form of integrated governance is not present at a national level.[324] The obstacle will also include how to implement the approach so that the risks, challenges and opportunities thereof are considered by interested parties.

## *4.6 Concluding remarks*

This chapter reviewed the existing energy legal framework for South Africa and whether the framework allows the water-energy nexus to be utilised and implemented to govern water resources more sustainably at coal fired power stations. This chapter has examined the regulatory framework for indications of 'nexus thinking' in order to establish a secure and sustainable future for water use at coal fired power stations.

Despite South Africa's regulatory framework as set out in chapter two and four above, energy laws rarely take water into account in a substantive manner, although it is clear that the sustainable management of water could benefit the energy security.[325] The problem regarding water use at coal fired power stations does not lie with the water or energy laws per se, but rather the implementation and integration thereof.[326] Energy laws do not form a coherent body with guiding principles and interpretive case law in the manner that characterises South Africa's water law. Therefore, more specific criteria are needed to sustainably "balance" water and energy needs.

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323 Simpson and Jewitt 2019 *Front. Environ. Sci.* 6.
324 Simpson and Jewitt 2019 *Front. Environ. Sci.* 6.
325 Mathetsa, Simatele, Rampedi, and Gericke *Journal of Energy in Southern Africa* 12.
326 Muller 2018 https://theconversation.com/south-africa-needs-good-water-management-not-new-water-laws-91253.

As this framework gains traction, it has to be utilised to achieve adequate water and energy security for all. The framework must, as the irreplaceable foundation of nexus thinking, simultaneously sustainably develop and protect the natural resources. The water-energy nexus holds promise for guiding policy development and governance structures in the sense that it can aid decision-makers by providing useful tools to model the nexus framework. Even though the water-energy nexus has not formally been made an official policy in South Africa, integrated water management has been adopted in the country and it could offer models for integrated laws to manage the water-energy nexus. It has been established that South Africa's water and energy regulatory frameworks have room for nexus thinking and that this approach is promising for sustainable water use at coal fired power stations.

# Chapter 5 – Concluding remarks

## *5.1 Background*

As the climate changes, and heat waves become more prevalent across the globe, the already scarce and limited natural water resources continue to dwindle. For this very reason, across the world,[327] many coal fired power plants have been shut down and replaced with renewable energy infrastructure.[328] South Africa, being a semi-arid country,[329] is mostly reliant on coal fired power plants to generate electricity. In fact, the country will continue to be reliant on coal for electricity generation for the foreseeable future. The newly erected Kusile power station is one of the world's largest coal-fired power plants.[330] These coal-fired power generation plants are however heavily dependent on water resources.[331] South Africa does not only face severe water shortages, but power outages are widespread and common throughout the country due to demand exceeding supply.[332] Due to the growing water scarcity, the sustainable use of water resources at coal-fired power stations is of particular importance. In fact, fact, water availability and access thereto are key factors in ensuring a sustainable future for South Africa. This mini-dissertation has therefore examined water usage at South Africa's coal power stations from a legal perspective.

This study focused on the fact that, in power generation, water and energy are interlinked, dependent on one another, to the extent that a nexus exists between them.

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327 In the United States of America alone, more than 100 coal fired power plants have been replaced with alternative methods of energy generation. Energy Information Administration *More than 100 coal fired power plants have been replaced or converted to natural gas since 2011* 1.

328 Gjorgiev and Sansavini 2018 *Applied Energy* 568.

329 Barradas, Shepherd and Theron *A review of South Africa's water sector* 1.

330 Power technology 2020 https://www.power-technology.com/projects/kusilepowerstation/#:~:text=in%20March%202008.-,Kusile%20power%20station%2C%20which%20is%20expected%20to%20become%20the%20world's,gas%20desulphurisation%20(FGD)%20technology.

331 Gjorgiev and Sansavini 2018 *Applied Energy* 569.

332 Naidoo and Vollgraaff *Bloomerg* 1.

## *5.2 Re-examining the research question and objectives*

The question that has underpinned this study is how and to what extent the South African water regulatory framework regulates water use at state owned coal power stations for a sustainable water and energy future. In order to address the research question, the following secondary objectives have been set:

1. To theoretically examine the existing water regulatory framework in relation to water use at South Africa's coal-fired power stations, while considering the overall impacts and the intensive water use for electricity production in South Africa.
2. To discuss the meaning and significance of a water-energy nexus approach in water governance at coal-fired power stations.
3. To assess whether South Africa's water and energy regulatory frameworks provide for nexuses that can contribute towards sustainable water use practices.
4. To distil from the analysis lessons learned and to make recommendations that can enhance the South African water regulatory framework to sustainably regulate water use at state owned coal power stations.

## *5.3 Structure of the analysis*

This study was divided into chapters in accordance with the focus of the various chapters' objectives. Chapter 1 introduced the background of the study and the problem statement, drawing attention to water and energy shortages in South Africa. Chapter 2 laid the theoretical foundations of South Africa's water regulatory framework and its relevance to coal-fired power stations. The analysis showed that the country's water regulatory framework consists of different legal instruments, and that most of these instruments strive to protect South Africa's natural water resources and sustainability thereof. The analysis also showed that Eskom's coal fired power stations have a history of non-compliance with water laws. Chapter 3 discussed the meaning and significance of a water-energy nexus approach in water governance at coal-fired power stations, suggesting the different applications of the water-energy nexus approach. Chapter 4 explored existing nexuses in the energy regulatory framework

and its relevance to coal fired power stations. This assisted in determining whether the energy framework allows the water-energy nexus to be implemented at coal fired power stations to govern water resources in a more sustainable manner. The chapter also discussed sustainable water use practises at said coal fired power stations. The final chapter re-examines the research question and objective of the study, providing the main findings and answering the research question.

## *5.4 Main findings*

The objectives of the study as stated in 5.2 above, translated into areas of focus for each of the chapters of this mini-dissertation. Each chapter investigated a dimension of the research question and in doing so, resulted in a set of main findings. These have been used to draw some conclusions and recommendations.

### 5.4.1 South Africa's seemingly comprehensive water regulatory framework

Chapter 2 examined South Africa's water regulatory framework from a legal perspective. The legal framework consists of sector specific legislation and policies as well as non-sector specific legislation. Sector specific legislation includes the *Constitution*,[333] the *WSA*,[334] the *NWA* [335] and policies like the *NWRS*1 & 2[336] and *IWRM*. Non-sector specific legislation includes *NEMA*,[337] *NEMBA*[338] and *NEMWA*.[339] The chapter has explained the *status quo*, as well as how water is used at coal fired power stations for cooling purposes.

South Africa possesses a new and seemingly adequate legal water regulatory framework. However, upon closer inspection it becomes clear that unsustainable water

333 *The Constitution of South Africa*, 1996.
334 The *WSA* 108 of 1997.
335 The *NWA* 36 of 1998.
336 Department Water Affairs & forestry *NWRS* 1 & 2.
337 *NEMA* 107 of 1998.
338 *NEMBA* 10 of 2004.
339 *NEMWA* 59 of 2008.

practises still persist in the energy sector. This discovery necessitated further research on the water-energy nexus concept.

### 5.4.2 The water-energy nexus as an opportunity for sustainable water use

Chapter 3 has introduced and considered the notion of the 'water-energy nexus' and emphasised the interconnectedness between water and energy. The chapter explored the history of the water-energy nexus, indicating that it is not a new concept, but is still relevant. The notion of a water-energy nexus was theoretically examined and explained. The nexus revealed that it has different functions and can be used and applied as either an analytical tool, a conceptual framework or as a discourse. The chapter has found that when following a nexus approach, the opportunity for sustainably improving water and energy security, emerge.

### 5.4.3 Existing nexuses in South Africa's water and energy regulatory framework

Chapter 4 has examined whether nexuses exist in South Africa's water and energy regulatory frameworks that can be utilised and implemented at the country's coal-fired power stations in order to enhance sustainable water use practices. The various pieces of energy legislation pertaining to coal energy showed potential for 'nexus thinking' but do not explicitly mention the water-energy nexus. Examples of existing nexuses include *IEP,* contained and required in the *White Paper on the Energy Policy* as well as in the *National Energy Bill*. Chapter 4 has examined whether 'nexus thinking' can alleviate water and energy pressures; whether the water-energy nexus addresses resource security, governance considerations associated with the water-energy nexus at coal fired power stations and the development of the water-energy nexus as a framework for achieving sustainable water use practises at coal fired power stations.

### 5.4.4 The Water-Energy Nexus as a Framework for achieving sustainable water use practises at coal fired power stations

The water-energy nexus approach can, and should be implemented as a framework for achieving sustainable water use practises at coal fired power stations in South Africa. Once implemented, the approach can aid in reducing water use for electricity generation. The approach can be used as a tool to assist decision makers with future

infrastructure planning in the country. The nexus approach can combine water and energy modelling, planning and management to develop practical methodologies that can be applied to operational tools.[340]

## *5.5 Recommendations*

The water-energy nexus emerged as a concept of integrated management of resource and may be understood as a framework that addresses interlinked issues in different sectors to achieve coherent and interconnected management and solutions to complex problems. This study unravelled the potential of the water-energy nexus to assist sustainable water use practises at coal fired power stations. The study revealed that the nexus framework must be utilised and applied at coal fired power stations by including sustainable water use practises in the electricity generation process and by making decisions that develops and protects water resources whilst securing energy production and availability. The nexus can provide useful tools to decision-makers to model the nexus framework. These tools include using the nexus as an analytical tool, a conceptual framework, or a scholarly discourse. Additionally, combining the water-energy nexus framework with integrated water management at coal fired power stations can aid in less water used during the energy generation process. This can be achieved by utilising the existing principles of integrated water management in South Africa and applying it to water use at coal fired power stations, complimentary to the water-energy nexus.

## *5.6 Future research agenda*

This study only focuses on the water and energy nexus for the purpose of water use in the electricity generation process at coal fired power stations. In addition to the water-energy nexus, there is a trend of aligning food security to the water-energy nexus. Research has indicated that 46.4% of South Africa's high capability arable land is situated in the Mpumalanga Province.[341] Currently, 61.3% of the surface area in the

340 World Bank Group *Modeling the water-energy nexus – How do water constraints effect energy planning in South Africa?* 2.
341 Simpson *The water-energy-food nexus: A Mpumalanga Province perspective* 1.

Mpumalanga Province is subject to mining and prospecting activities.[342] Most of Eskom's coal fired power stations are located in Mpumalanga as the Province has vast coal fields. Most of the open cast mining activities occur on high potential arable soil, bringing the water-energy-food nexus components into sharp focus.[343] Coal-based energy is threatening food production and water security in Mpumalanga.[344]

## *5.5 Answering the research question of the mini-dissertation*

The research question was how and to what extent the South African water regulatory framework regulates water use at state owned coal power stations for a sustainable water and energy future.

Retrospectively seen, this study has found that even though South Africa has new and seemingly sufficient water and energy laws, water use at Eskom's coal fired power stations are poorly regulated. The water regulatory framework requires water licenses for certain water uses, however Eskom so often do not comply with said licenses. The water and energy regulatory frameworks do however contain indications of 'nexus thinking'. Existing nexuses between water and energy can be seen when considering the language used by the legislator. This language includes phrases like 'cross-sectoral management' and 'integrated planning'. This 'nexus thinking' can alleviate water and energy pressures by facilitating coordinated planning between the respective water and energy sectors. In fact, the water-energy nexus addresses resource security by requiring sustainable development to be at the centre of all resource-related decisions. Also, governance considerations associated with the water-energy nexus at coal-fired power stations include the integration of the water and energy sectors. The development of the water-energy nexus as a framework for achieving sustainable water use practises at coal fired power stations will therefore enhance these practises by facilitating cross-sectoral co-ordination and planning.

342 Simpson *The water-energy-food nexus: A Mpumalanga Province perspective* 1.
343 Simpson *The water-energy-food nexus: A Mpumalanga Province perspective* 1,2.

South Africa's water and energy regulatory frameworks show intentions of 'nexus thinking'. In most cases the legislator refers to "integrated management"[345] and "cross-sectoral coordination.[346] Integrated water management has the potential to provide models for integrated laws that, by means of the water-energy nexus that impact governance, have the potential to enhance more sustainable water use practises at coal fired power stations.

## *5.6 Conclusion*

The topic of this dissertation is inevitably the link between water and energy. The intertwined issues of water scarcity and energy use are prominent influences within the broader water sustainability paradigm. Water and energy use on power plants are coupled by production and consumption, following an operational focus on infrastructure and technology.

The water and energy sectors of South Africa continue to experience systemic challenges such as water shortages[347] and power outages.[348] For this reason, 'nexus thinking' has become a necessity within the water and energy regulatory frameworks of South Africa for a secure and sustainable future. Water and energy are fundamental to South Africa's growing economy. To create a sustainable future, it is critical to seek holistic and integrated solutions for water and energy challenges.

Water use at South Africa's coal fired power plants are regulated poorly. The interrelationships between water and energy are largely ignored as Eskom more often than not, contravenes water laws or operates without valid water use licences. The water-energy nexus framework can assist decision-makers and stakeholders to develop a framework for the sustainable use of water in the electricity generation

345 See paragraph 4.2.2, 4.2.4, 4.2.5, 4.2.6 and 4.3.
346 See paragraph 4.2.2.
347 Donnenfeld, Crookes and Hedden *A delicate balance: water scarcity in South Africa* 2.
348 Sguazzin and Naidoo 2020 https://www.bloomberg.com/news/articles/2020-07-10/south-africa-hit-by-power-cuts-even-after-maintenance-boosted.

process. The framework can be applied and used as a tool for policymakers in addressing water and energy related issues.

# BIBLIOGRAPHY

## *Literature*


Ackerman and Fisher "Is there a water-energy nexus in electricity generation? Long-term scenarios for the Western United States"

Ackerman F and Fisher J "Is there a water-energy nexus in electricity generation? Long-term scenarios for the Western United States" 2013 *Energy policy* 235-241

Algotsson and Murombo *Water supply and sanitation in South Africa: Environmental rights and municipal accountability*

Algotsson E and Murombo T *Water supply and sanitation in South Africa: Environmental rights and municipal accountability* (2009) available at https://cer.org.za/wp-content/uploads/2011/11/LHR-DBSA_Water_Report.pdf accessed 24 June 2021

Allouche "The birth and spread of IWRM – A case study of global policy Diffusion and Translation"

Allouche J "The birth and spread of IWRM – A case study of global policy Diffusion and Translation" 2016 *Water Alternatives* 9(3) 412-433

Allouche "Technical Veil, Hidden Politics: Interrogating the Power Linkages behind the Nexus"

Allouche J "Technical Veil, Hidden Politics: Interrogating the Power Linkages behind the Nexus" 2015 *Water Alternatives* 610-626

Apfelbaum, Duvall, Nelson, Mensing, Bengtson, Eppich and Thompson *Wetland Water Cooling Partnership: The Use of Constructed Wetlands to Enhance Thermoelectric Power Plant Cooling and Mitigate the Demand of Surface Water Use*

Apfelbaum S I, Duvall K W, Nelson T M, Mensing B M, Bengtson H H, Eppich J D and Thompson R L *Wetland Water Cooling Partnership: The Use of Constructed Wetlands to Enhance Thermoelectric Power Plant Cooling and Mitigate the Demand of Surface Water Use* (2013) available at https://www.osti.gov/servlets/purl/1121759 accessed 18 June 2021

Asensio, Gil, Moya, Peiro and Martin "Decision-making tools for sustainable planning and conceptual framework for the energy-water-food nexus"

Asensio ER, Gil AP, Moya FJG, Peiro JB and Martin MS "Decision-making tools for sustainable planning and conceptual framework for the energy-water-food nexus" 2020 *Energy Reports* 4-15

Aster *What is the water-energy nexus?*

Aster N *What is the water-energy nexus?* (2012) available at https://www.triplepundit.com/story/2012/what-water-energy-nexus/59796 accessed 28 November 2021

Backeberg "Water institutional reforms in South Africa"

Backeberg G R "Water institutional reforms in South Africa" 2005 *Water Policy* 107-123

Barnes and De Klerk *South Africa's multi-party constitutional negotiation process*

Barnes C and De Klerk E *South Africa's multi-party constitutional negotiation process* (2002) available at https://rc-services-assets.s3.eu-west-1.amazonaws.com/s3fs-public/Accord%2013_5South%20Africa%27s%20multi-party%20constitutional%20negotiation%20process_2002_ENG.pdf accessed 27 July 2021

Barradas, Shepherd and Theron *A review of South Africa's water sector*

Barradas S, Shepherd D and Theron R (eds) A review of South Africa's water sector (Creamer Media's Water Report 2016)

Bazilian "Considering the energy, water and food nexus: Towards an integrated modelling approach"

Bazilian M "Considering the energy, water and food nexus: Towards an integrated modelling approach" 2011 *Energy policy* 7896-7906

Bega "We struggle for water, but power stations and coal mines don't"

Bega S "We struggle for water, but power stations and coal mines don't" *Mail & Guardian* (26 November 2020) 1.

Belinskij "Water-Energy-Food Nexus within the Framework of International Water Law"

Belinskij A "Water-Energy-Food Nexus within the Framework of International Water Law" 2015 *Water* 5396-5415

Bhaduri "Sustainability in the water-energy-food nexus"

Bhaduri A "Sustainability in the water-energy-food nexus" 2015 *Water International* 723-732

Biswas "Integrated Water Resources Management: Is it working?"

Biswas A K "Integrated Water Resources Management: Is it working?" 2008 *International Journal of Water Resource Development 24(1)* 5-22

Blewitt *Understanding sustainable development*

Blewitt J *Understanding sustainable development* 2nd ed (Routledge 2014)

Boas, Biermann and Kanie "Cross-sectoral strategies in global sustainability governance: towards a nexus approach"

Boas I, Biermann F and Kanie N "Cross-sectoral strategies in global sustainability governance: towards a nexus approach" 2016 Int Environ Agreements

Boulding *The economics of the coming spaceship earth*

Boulding *The economics of the coming spaceship earth* (1966) available at http://www.ub.edu/prometheus21/articulos/obsprometheus/BOULDING.pdf accessed 22 March 2021

Buffalo City Metropolitan Municipality *Integrated Development Plan review of Buffalo City Metropolitan Municipality*

Buffalo City Metropolitan Municipality *Integrated Development Plan review of Buffalo City Metropolitan Municipality* (2021) available at https://buffalocity.gov.za/CM/uploads/documents/20203006061593513502 1.AnnexureA-BCMMIDPReview2020_2021FINAL20JUNE2020.pdf accessed 3 July 2021

Carpenter *Water conservation in coal-fired power plants*

Carpenter A M *Water conservation in coal-fired power plants* (2017) available at https://usea.org/sites/default/files/Water%20conservation%20in%20coal%20fired%20power%20plants%20-%20ccc275.pdf accessed 2 December 2020

Classen "Integrated Water Resource Management in South Africa"

Classen M "Integrated Water Resource Management in South Africa" 2013 *International Journal of Water Governance* 323-338

Coetzee *Sustainable development in South African environmental law and its relationship with the National Development Plan*

Coetzee J H *Sustainable development in South African environmental law and its relationship with the National Development Plan* (LLM-dissertation North-West University 2016)

De Bod *The South African water management framework: Lethabo power station as a case study*

De Bod S *The South African water management framework: Lethabo power station as a case study* (Master of Engineering in Development and Management-dissertation North-West University Potchefstroom 2012)

De Coning and Sherwill *An assessment of the water policy process in South Africa*

De Coning C and Sherwill T *An assessment of the water policy process in South Africa* (2004) available at http://www.wrc.org.za/wp-content/uploads/mdocs/TT232-04.pdf accessed 27 June 2021

Department of Energy *South African Energy Synopsis*

Department of Energy *South African Energy Synopsis* (2010) available at www.energy.gov.za/files/media/explained/2010/South_African_Energy_Synopsis_2010.pdf accessed 6 March 2019

Department of Environmental Affairs and Tourism *National Framework for Sustainable Development*

Department of Environmental Affairs and Tourism *National Framework for Sustainable Development* (2008) available at https://www.gov.za/sites/default/files/gcis_document/201409/nationalframeworkforsustainabledevelopmenta0.pdf accessed 22 March 2021

Department of Water Affairs *National Water Recourse Strategy*

Department of Water Affairs *National Resource Strategy* (2013) available at http://www.dwa.gov.za/documents/Other/Strategic%20Plan/NWRS2-Final-email-version.pdf accessed 27 February 2019

Department of Water Affairs & Forestry *Water for Growth & Development Framework*

Department of Water Affairs & Forestry *Water for Growth & Development Framework* (2009) available at www.dwaf.gov.za/WFGD/documents/WFGD_framework.pdf accessed 5 March 2019

Department of Water and Sanitation *Strategic overview of the Water sector in South Africa*

Department of Water and Sanitation *Strategic overview of the Water sector in South Africa* (2018) available at http://www.dwaf.gov.za/Downloads/WS/Macro_Planning_Products/STRATEGIC%20OVERVIEW%20OF%20WATER%20SERVICES/2018_May_A6_SOWSSA_HQ.pdf accessed 21 March 2019

Department of Water and Sanitation *South Africa Yearbook 2015/2016: Water and Sanitations*

Department of Water and Sanitation *South Africa Yearbook 2015/2016: Water and Sanitations* 2016 available at https://www.gcis.gov.za/sites/default/files/docs/resourcecentre/yearbook/WaterSanitation-SAYB1516.pdf accessed 30 November 2020

Department of Water and Sanitation *Water for Growth and Development Framework & National Framework for Sustainable Development for South Africa*

Department of Water and Sanitation 2009 *Water for Growth and Development Framework & National Framework for Sustainable Development for South Africa* available at https://pmg.org.za/committee-meeting/10678/ accessed 30 November 2020

Donnenfeld, Crookes and Hedden *A delicate balance: water scarcity in South Africa*

Donnenfeld Z, Crookes C and Hedden S *A delicate balance: water scarcity in South Africa* (2018) available at https://issafrica.s3.amazonaws.com/site/uploads/sar13-2.pdf accessed 21 September 2020

Du Plessis "Energy efficiency and the law: A multidisciplinary approach"

Du Plessis W "Energy efficiency and the law: A multidisciplinary approach" 2015 SAJS 1-8

Du Plessis *Energy law in South Africa*

Du Plessis WJ *Energy law in South Africa* 2nd edition (Wolters Kluwer 2020)

Du Plessis *Freshwater challenges of South Africa and its Upper Vaal river*

Du Plessis A *Freshwater challenges of South Africa and its Upper Vaal river* (Springer Cham Switzerland 2017)

Du Pisani "Sustainable development – historical roots of the concept"

Du Pisani J A "Sustainable development – historical roots of the concept" 2007 *Environmental Sciences* 83-96

Dublin-Rio Principles "The Dublin Statement on Water and Sustainable Development"

Dublin-Rio Principles "The Dublin Statement on Water and Sustainable Development" at the *International Conference on Water and the Environment (ICWE)*, on (26-31 January 1992 Rio de Janeiro) 1-3

Eberhard "The political economy of power sector reform in South Africa"

Eberhard A "The political economy of power sector reform in South Africa" in *Political Economy of Power Market Reform conference* (19-20 February 2003 Stanford University) 1-38

Edokpayi, Rogawski, Kahler, Hill, Reynolds, Nyathi, Smith, Odiyo, Samie, Bessong and Dillingham "Challenges to Sustainable Safe Drinking Water: A Case Study of Water Quality and Use across Seasons in Rural Communities in Limpopo Province, South Africa"

Edokpayi J N, Rogawski E T, Kahler D M, Hill C L, Reynolds C, Nyathi E, Smit J A, Odiyo J O, Samie A, Bessong P and Dillingham R "Challenges to Sustainable Safe Drinking Water: A Case Study of Water Quality and Use across Seasons in Rural Communities in Limpopo Province, South Africa" 2018 *Water* 2-18

Endo, Tsurita, Burnett and Orencio "A review of the current state of research on the water,energy, and food nexus"

Endo A, Tsurita I, Burnett K and Orencio P M "A review of the current state of research on the water,energy, and food nexus" 2017 *Journal of Hydrology: Regional Studies* 20-30

Energy Information Administration *More than 100 coal fired power plants have been replaced or converted to natural gas since 2011*

Energy Information Administration *More than 100 coal fired power plants have been replaced or converted to natural gas since 2011* 2020 available at https://www.eia.gov/todayinenergy/detail.php?id=44636 accessed 21 November 2021

Energy Working Group *Water Energy Nexus: Coal-based power generation and conversion – saving water*

Energy Working Group *Water Energy Nexus: Coal-based power generation and conversion – saving water* (2016) available at https://www.apec.org/Publications/2017/02/Water-Energy-Nexus-Coal-Based-Power-Generation-and-Conversion---Saving-Water accessed 27 February 2020

Environmental Monitoring Group *The energy-water nexus: energy demand on water resources*

Environmental Monitoring Group *The energy-water nexus: energy demand on water resources* (2012) available at http://www.emg.org.za/images/stories/water_cl_ch/water-energy-nexus_to%20print.pdf accessed 7 October 2019

Eskom Holdings SOC Limited *Environmental Management Strategy*

Eskom Holdings SOC Limited *Environmental Management Strategy* (2014) available at https://cer.org.za/wp-content/uploads/2018/05/Doc-1.3-a-Esk-env-strat-aug-14.pdf accessed 27 April 2021

Eskom Holdings SOC Limited *Eskom's revised Coal Ash Strategy and Implementation Progress*

Eskom Holdings SOC Limited *Eskom's revised Coal Ash Strategy and Implementation Progress* (2016) available at http://nla.org.za/webfiles/conferences/2016/Manuscripts/Tuesday,%2027%20September%202016/T308%20ESKOM%20revised%20coal%20ash%20strategy%20and%20implementation%20progress.pdf accessed 7 March 2019

Eskom Holdings Limited *Annual Report 2009*

Eskom Holdings Limited *Annual Report 2009* (2009) available at http://www.financialresults.co.za/eskom_ar2009/ar_2009/downloads/01_profile.pdf accessed 11 March 2019

Eskom Holdings Limited *Integrated Report*

Eskom Holdings Limited *Integrated Report* (2018) available at http://www.eskom.co.za/IR2018/Documents/Eskom2018IntegratedReport.pdf accessed 17 March 2019.

Eskom Holdings Limited *The Eskom Factor*

Eskom Holdings Limited *The Eskom Factor* (2011) available at http://www.eskom.co.za/OurCompany/SustainableDevelopment/Documents/EskomFactor.pdf accessed 6 March 2019

Eskom Holdings Limited *Water Management*

Eskom Holdings Limited *Water Management* (2021) available at https://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/Reduction_In_Water_Consumption.aspx accessed 18 June 2021

Forrest and Loate Coal, Water and Mining flowing badly

Forrest K and Loate L *Coal, Water and Mining flowing badly* (2017) https://www.fes-southafrica.org/fileadmin/user_upload/coal__water_and_minig_flowing_badly.pdf accessed 10 September 2020

Fuo 'The Right of Access to Sufficient Water in South Africa: Comments on *Federation for Sustainable Environment and Others v Minister of Water Affairs* [2012] ZAGPPHC 128'

Fuo ON 2013 "The Right of Access to Sufficient Water in South Africa: Comments on *Federation for Sustainable Environment and Others v Minister of Water Affairs* [2012] ZAGPPHC 128" *Murdoch University Law Review* 20(2) 21-37

Fürst, Luque and Geneletti "Nexus thinking – how ecosystem services can contribute to enhancing the cross-scale and cross-sectoral coherence between land use, special planning and policy-making"

Fürst C, Luque S and Geneletti D 2017 "Nexus thinking – how ecosystem services can contribute to enhancing the cross-scale and cross-sectoral coherence between land use, special planning and policy-making" *International Journal of Biodiversity Science, ecosystem services & management* 412-421

Gjorgiev and Sansavini "Electrical power generation under policy constrained water-energy nexus"

Gjorgiev B and Sansavini G "Electrical power generation under policy constrained water-energy nexus" 2018 Applied Energy 568-579

Glazewski *The Legal Framework for Renewable Energy in South Africa*

Glazewski *JThe Legal Framework for Renewable Energy in South Africa* (2005) available at https://www.un.org/esa/sustdev/sdissues/energy/op/parliamentarian_forum/glazewski_re_sa.pdf accessed 11 April 2021

Gleick "Energy implications of bottled water"

Gleick P H "Energy implications of bottled water" 2009 *Environ. Res. Lett.* 1-6

Gleick "Water in crisis: paths to sustainable water use"

Gleick P H "Water in crisis: paths to sustainable water use" 1998 *Ecological Applications* 571-579

Godden "The water-energy nexus"

Godden L "The water-energy nexus" in Faure M (eds) *Elgar Encyclopedia of Environmental law* (Edward Elgar Publishing 2021) 72-85

Goldsmith *A blueprint for survival*

Goldsmith E *A blueprint for survival* 1st ed (Tom Stacey Ltd London 1972)

Green Gain Consulting *Environmental Legal Compliance Audit Report*

Green Gain Consulting *Environmental Legal Compliance Audit Report* (2016) available at https://cer.org.za/wp-content/uploads/2016/07/Majuba-Power-Station-_-Environmental-legal-compliance-audit.pdf accessed 17 March 2018

Greenpeace *Water Hungry Coal: Burning South Africa's Water to Produce Electricity*

Greenpeace *Water Hungry Coal: Burning South Africa's Water to Produce Electricity* (2012) available at https://storage.googleapis.com/planet4-africa-stateless/2018/10/b7fd2949-b7fd2949-waterhungrycoal.pdf accessed 5 March 2019

Grigg "IWRM and the nexus approach: Versatile concepts for water resource education"

Grigg N S "IWRM and the nexus approach: Versatile concepts for water resource education" 2019 *Journal of Contemporary Water Research & Education* 24-34

Hardy "Evaluation of Spain's water-energy nexus"

Hardy L "Evaluation of Spain's water-energy nexus" 2012 *International Journal of Water Resource Development* 151-170

Harwood "In search of a (WEF) nexus approach"

Harwood S A "In search of a (WEF) nexus approach" 2018 *Environmental Science Policy* 79-85

Heffron, Ronne, Tomain, Bradbrook and Talus "A treatise for energy law"

Heffron R J, Ronne A, Tomain J P, Bradbrook A and Talus K "A treatise for energy law" 2018 *Journal of World Energy Law and Business* 34-48

Heffron and Talus "The evolution of energy law and energy jurisprudence: Insights for energy analysts and researchers"

Heffron R J and Talus K "The evolution of energy law and energy jurisprudence: Insights for energy analysts and researchers" 2016 *ERSS* 1-10

Hellegers "Interactions between water, energy, food and environment: evolving perspectives and policy issues"

Hellegers P "Interactions between water, energy, food and environment: evolving perspectives and policy issues" 2008 *Water Policy* 1-10

Hoff 'Understanding the nexus'

Hoff H 'Understanding the nexus' in Background Paper for the Bonn2011 Conference: *The Water, Energy and Food Security Nexus. Stockholm Environment Institute* (16-18 November 2011 Stockholm)

Hove *et al* "'Water is life': developing community participation for clean water in rural South Africa"

Hove J *et al* "'Water is life': developing community participation for clean water in rural South Africa" 2019 *BMJ Global Health* 1-13.

Howells "Integrated analysis of climate change, land-use, energy and water strategies"

Howells M "Integrated analysis of climate change, land-use, energy and water strategies" 2013 *Nature Climate Change* 621-626

Hussey and Pittock "The energy-water nexus: Managing the links between energy and water for a sustainable future"

Hussey K and Pittock J "The energy-water nexus: Managing the links between energy and water for a sustainable future" 2012 *Ecology and Society*

Itayi, Mohan and Saito "Understanding the conceptual frameworks and methods of the food-energy-water nexus at the household level for development-oriented policy support: a systematic review"

Itayi CL, Mohan G and Saito O "Understanding the conceptual frameworks and methods of the food-energy-water nexus at the household level for development-oriented policy support: a systematic review" 2021 *Environ. Res. Lett.* 1-33

Karuppia and Gupta *Toxicity of and metals in coal combustion ash leachate*

Karuppia M and Gupta G "Toxicity of and Metals in Coal Combustion Ash Leachate" 1997 *Journal of Hazardous Materials* 53-58

Kenway *et al* "The connection between water and energy in cities: A review"

Kenway S *et al* "The connection between water and energy in cities: A review" 2011 *Water science and Technology* 1983-1990

Kidd "Water governance, management and use"

Kidd M "Water governance, management and use" in Kameri-Mbote, Paterson, Ruppel, Orubebe and Kan Yogo (eds) Law / Environment / Africa (Nomos Verlagsgesellschaft, Baden-Baden, Germany 2019) 413-427

King and Weber "Thirst for energy"

King C and Webber M E "Thirst for energy" 2008 *Nature geoscience* 283-286

Kotzé "Improving unsustainable environmental governance in South Africa: The case for holistic governance"

Kotzé L J "Improving unsustainable environmental governance in South Africa: The case for holistic governance" 2006 *PER* 75-118

Kotzé "On integrated environmental governance in the Netherlands: a comparative study in reforms for South Africa"

Kotzé L J "On integrated environmental governance in the Netherlands: a comparative study in reforms for South Africa" 2007 Institute of Foreign and Comparative Law 472-508

Kurian "The Water-Energy-Food Nexus: Trade-Offs, Thresholds and Transdisciplinary Approaches to Sustainable Development"

Kurian "The Water-Energy-Food Nexus: Trade-Offs, Thresholds and Transdisciplinary Approaches to Sustainable Development" 2017 *Environmental science and policy* 68 97-106

Lambooy "Corporate social responsiility"

Lambooy T "Corporate social responsiility" 2011 *Journal of cleaner production* 852-866

Larsen and Drews "Water use in electricity generation for water-energy nexus analyses: The European case"

Larsen MAD and Drews M "Water use in electricity generation for water-energy nexus analyses: The European case" 2019 *Science of the Total Environment* 2044-2058

Larsen, Petrovic, Engstrom, Drews, Liersch, Karlsson and Howells "Challenges of data availability: Analysing the water-energy nexus in electricity generation"

Larsen M A D, Petrovic S, Engstrom R E, Drews M, Liersch S, Karlsson K B and Howells H "Challenges of data availability: Analysing the water-energy nexus in electricity generation" 2019 *Energy Strategy Reviews* 1-14

Leese and Meisch "Securitising sustainability? Questioning the 'Water, energy and food-security nexus'"

Leese M and Meisch S "Securitising sustainability? Questioning the 'Water, energy and food-security nexus' " 2015 *Water Alternatives* 695-709

Li Understanding the water-energy nexus: A case study of Ningxia

Li X Understanding the water-energy nexus: A case study of Ningxia (Master's thesis Uppsala University 2014)

Liu, Hull, Godfray, Timan, Gleick, Hoff, Pahl-Wostl, Xu, Chung and Li "Nexus approaches to global sustainable development"

Liu J, Hull V, Godfray H C J, Tilman D, Gleick P, Hoff H, Pahl-Wostl C, Xu Z, Chung M G and Li S "Nexus approaches to global sustainable development" 2018 *Nature Sustainability* 466-476

Mabhaudhi, Simpson, Badenhorst, Mohammed, Motongera, Senzanje and Jewitt *Assessing the state of the water-energy-food (WEF) nexus in South Africa*

Mabhaudhi T, Simpson G, Badenhorst J, Mohammed M, Motongera T, Senzanje A and Jewitt *A Assessing the state of the water-energy-food (WEF) nexus in South Africa* (2018) available at http://www.wrc.org.za/wp-content/uploads/mdocs/KV%20365-18.pdf accessed 15 June 2021

Madigele, Snowball and Fraser "Water, water everywhere: Is Integrated Water Resource Management the right institutional prescription for South Africa's water management challenges?"

Madigele, Snowball and Fraser "Water, water everywhere: Is Integrated Water Resource Management the right institutional prescription for South Africa's water management challenges?" 2015 *International Journal of Water Governance* 323-338

Markantonis "Can the implementation of the water-energy-food nexus support economic growth in the Mediterranean region? The current status and the way forward"

Markantonis V "Can the implementation of the water-energy-food nexus support economic growth in the Mediterranean region? The current status and the way forward" 2019 *Frontiers in Environmental Science* 1-11

Mathetsa, Simatele, Rampedi and Gericke "Perspectives on integrated water resource management and its relevance in understanding the water-energy-climate change nexus in South Africa"

Mathetsa S M, Simatele M D, Rampedi I T and Gericke G "Perspectives on integrated water resource management and its relevance in understanding the water-energy-climate change nexus in South Africa" 2019 *Journal of Energy in Southern Africa* 11-21

McCarthy "The impact of acid mine drainage in South Africa"

McCarthy T S "The impact of acid mine drainage in South Africa" 2011 *S Afr J Sci* 1-7

McDonald "Water on an urban planet: Urbanization and the reach of urban water infrastructure"

McDonald R I "Water on an urban planet: Urbanization and the reach of urban water infrastructure" 2014 *Global Environmental Change* 96-105

Molobela and Sinha "Management of water resources in South Africa: A review"

Molobela I P and Sinha P 2011 "Management of water resources in South Africa: A review" *Afr. J. Environ. Sci. Technol.* 993-1002

Movik, Mehta, van Koppen and Denby "Emergence, Interpretations and Translations of IWRM in South Africa"

Movik S, Mehta L, van Koppen B and Denby K 2016 "Emergence, Interpretations and Translations of IWRM in South Africa" *Water Alternatives 9(3)* 456-472

Munawer "Human health and environmental impacts of coal combustion and post-combustion wastes"

Munawer M E 2018 "Human health and environmental impacts of coal combustion and post-combustion wastes" *Journal of Sustainable Mining* 87-96

Munnik *Water risks of coal driven mega projects in Limpopo: the MCWAP and the EMSEZ*

Munnik V *Water risks of coal driven mega projects in Limpopo: the MCWAP and the EMSEZ* (2020) available at https://www.researchgate.net/publication/341160046_Water_risks_of_coal_driven_mega_projects_in_Limpopo_the_MCWAP_and_the_EMSEZ accessed 19 June 2021

Muromo "Regulating energy in South Africa: enabling sustainable energy by integrating energy and environmental regulation"

Muromo T "Regulating energy in South Africa: enabling sustainable energy by integrating energy and environmental regulation" 2015 *Journal of Energy & Natural Resources Law* 320-348

Murrant, Quinn and Chapman "The water-energy nexus: future water resource availability and its implications on UK thermal power generation"
Murrant D, Quinn A and Chapman L 2015 "The water-energy nexus: future water resource availability and its implications on UK thermal power generation" *Water and Environment Journal* 307-319

Mutamba "Water security: Is South Africa optimally pursuing its options?"
Mutamba J 2019 "Water security: Is South Africa optimally pursuing its options?" *Water and Society* 47-54

Naidoo and Vollgraaff "South Africa hit by record blackouts, raising recession risk"
Naidoo P and Vollgraaff R "South Africa hit by record blackouts, raising recession risk" *Bloomberg* (9 ecember 2019) 1

National Academy of Sciences, National Academy of Engineering, and National Research Council "Renewable electricity generation technologies"
National Academy of Sciences, National Academy of Engineering, and National Research Council "Renewable electricity generation technologies" in *Electricity from renewable resources* (Washington, DC: The National Academies Press 2010) 67-86

Nhamo, Mabhaudhi, Mpandeli, Dickens, Nhemachena, Senzanje, Naidoo, Liphadzi and Modi "An integrative analytical model for the water-energy-food nexus: South Africa case study"
Nhamo L, Mabhaudhi T, Mpandeli S, Dickens C, Nhemachena C, Senzanje A, Naidoo D, Liphadzi S and Modi A 2020 "An integrative analytical model for the water-energy-food nexus: South Africa case study" *Environmental Science and Policy* 15-24

Olivier "The relevance of 'soft law' as a source of international human rights"
Olivier M "The relevance of 'soft law' as a source of international human rights" 2002 *CILJSA* 289-307

Oyewo "Pathway towards achieving 100% renewable electricity by 2050 for South Africa"

Oyewo A S "Pathway towards achieving 100% renewable electricity by 2050 for South Africa" 2019 *Solar Energy* 549-565

Pahl-Wostl, Gorris, Jager, Koch, Lebel, Stein, Venghaus, Witchanachchi "Scale-related governance challenges in the water-energy-food nexus: toward a diagnostic approach"

Pahl-Wostl C, Gorris P, Jager N, Koch L, Lebel L, Stein C, Venghaus S, Witchanachchi S "Scale-related governance challenges in the water-energy-food nexus: toward a diagnostic approach" 2020 *Sustainability Science* 615-629

Pardoe "Climate change and the water–energy–food nexus: insights from policy and practice in Tanzania"

Pardoe J "Climate change and the water–energy–food nexus: insights from policy and practice in Tanzania" 2017 *Climate Policy* 863-877

Radcliffe "The water energy nexus in Australia – The outcome of two crises"

Radcliffe J C "The water energy nexus in Australia – The outcome of two crises" 2018 Water-Energy Nexus 66-85

Rao *et al* "Technology and engineering of the water-energy nexus"

Rao P *et al* "Technology and engineering of the water-energy nexus" 2017 *Annu. Rev. Environ. Resour.* 407-437

Percival and Homer-Dixon "Environmental Scarcity and Violent Conflict: The Case of South Africa"

Percival V and Homer-Dixon T "Environmental Scarcity and Violent Conflict: The Case of South Africa" 1998 *Journal of Peace Research* 279-298

Robins "'Day Zero', Hydraulic citizenship and the defence of the commons in Cape Town: A case study of the Politics of water and its Infrastructures"

Robins S "'Day Zero', Hydraulic citizenship and the defence of the commons in Cape Town: A case study of the Politics of water and its Infrastructures" 2019 *Journal of Southern African Studies* 5-29

Saladini, Betti, Ferragina, Bouraoui, Cupertino, Canitano, Gigliotti, Autino, Pulselli, Riccaboni, Bidoglio and Bastianoni "Linking the water-energy-food nexus and sustainable development indicators for the Mediterranean region"

Saladini F, Betti G, Ferragina E, Bouraoui F, Cupertino S, Canitano G, Gigliotti M, Autino A, Pulselli F M, Riccaboni A, Bidoglio G and Bastianoni S "Linking the water-energy-food nexus and sustainable development indicators for the Mediterranean region" 2018 *Ecological Indicators* 689-697

Sanchez, Seliger, Fahl, De Felice, Quarda and Farinosi "Freshwater use of the energy sector in Africa"

Sanchez R G, Seliger R, Fahl F, De Felice L, Quarda T and Farinosi F "Freshwater use of the energy sector in Africa" 2020 *Applied energy* 1-19

Savannah Environmental (2013)

Savannah Environmental *Environmental Impact Assessment Report for the proposed Thabametsi coal-fired power station on a site near Lephalale, Limpopo province* (2013) available at https://sahris.sahra.org.za/sites/default/files/additionaldocs/App%20L%20-%20Surface%20Water.pdf accessed 16 May 2019

Schnoor "Water – Energy Nexus"

Schnoor J L "Water – Energy Nexus" 2011 *Environ. Sci. Technol.* 5065

Scott "Policy and institutional dimensions of the water-energy nexus"

Scott C A "Policy and institutional dimensions of the water-energy nexus" 2011 *Energy policy* 6622-6630

Shannak, Marey and Vittorio "Moving from theory to practice in the water-energy-food nexus: An evaluation of existing models and frameworks"

Shannak S, Marey D and Vittorio M 2018 "Moving from theory to practice in the water-energy-food nexus: An evaluation of existing models and frameworks" *Water-Energy Nexus* 17-25

Shrestha, Kafle, and Pandey "Evaluation of index-overlay methods for groundwater vulnerability and risk assessment in Kathmandu Valley, Nepal"
Shrestha S, Kafle R, and Pandey V P "Evaluation of index-overlay methods for groundwater vulnerability and risk assessment in Kathmandu Valley, Nepal" 2017 *Science of the Total Environment* 779-790

Simpson *The water-energy-food nexus: A Mpumalanga Province perspective*
Simpson G B *The water-energy-food nexus: A Mpumalanga Province perspective* (2017) available at https://www.researchgate.net/publication/340165788_The_Water-Energy-Food_Nexus_A_Mpumalanga_Province_Perspective accessed 6 December 2021

Simpson and Jewitt "The development of the water-energy-food nexus as a framework for achieving resource security: A review"
Simpson G B and Jewitt G P W "The development of the water-energy-food nexus as a framework for achieving resource security: A review" 2019 *Frontiers in Environmnetal Science* 1-9

Smedley "Can 'nexus thinking' alleviate global water, food and energy pressures?"
Smedley T "Can 'nexus thinking' alleviate global water, food and energy pressures?" *The Guardian* (25 January 2013)

Solanes "Integrated Water Management from the perspective of the Dublin Principles"
Solanes M "Integrated Water Management from the perspective of the Dublin Principles" 1992 *Cepal Review 64* 165-184

Steele *Water Hungry Coal: Burning South Africa's Water to Produce Electricity*
Steele M Water Hungry Coal: Burning South Africa's Water to Produce Electricity (2012) available at https://storage.googleapis.com/planet4-africa-stateless/2018/10/b7fd2949-b7fd2949-waterhungrycoal.pdf accessed 5 March 2019, 1 June 2020, 10 September 2020

Stockholm Environment Institute "Introduction and context"

Stockholm Environment Institute "Introduction and context" in the Background paper for the Bonn 2011 Nexus Conference: The water, energy and food security nexus (16-18 November 2011 Bonn)

Tewari "A detailed analysis of evolution of water rights in South Africa: An account of three and a half centuries from 1652 AD to present"

Tewari D D "A detailed analysis of evolution of water rights in South Africa: An account of three and a half centuries from 1652 AD to present" 2009 *Water SA* 693-710

The International Water Association *Integrated Water Resource Management: Basic Concepts*

The International Water Association *Integrated Water Resource Management: Basic Concepts* (2012) available at https://www.iwapublishing.com/news/integrated-water-resources-management-basic-concepts accessed 28 November 2021

Thompson *Water law: a practical approach to resource management & the provision of services*

Thompson H *Water law: a practical approach to resource management & the provision of services* (Juta Cape Town 2006)

Thopil and Pouris "Water usage forecasting in coal-based electricity generation: The case of South Africa"

Thopil GA and Pouris A "Water usage forecasting in coal-based electricity generation: The case of South Africa" 2015 *Energy Procedia* 2813-2818

Trenberth "The impact of climate change and variability on heavy precipitation, floods, and droughts"

Trenberth K E "The impact of climate change and variability on heavy precipitation, floods, and droughts" in Anderson M G and McDonnell J J (eds) *Encyclopedia of Hydrological Sciences* (Wiley 2006) 1-11

Trollip, Butler, Burton, Caetano and Godinho "Energy security in South Africa"

Trollip H, Butler A, Burton J, Caetano T and Godinho C 2014 "Energy security in South Africa" *MAPS* 1-32

United Nations "Conference on the Human Environment"

United Nations "Conference on the Human Environment" in *United Nations Conference on the Human Environment* (5-16 June 1972 Stockholm)

United Nations "Sustainable Development Goals"

United Nations "Sustainable Development Goals" in *United Nations Conference on Sustainable Development* (20-22 June 2012 Rio de Janeiro)

United Nations "Report of the World Summit on Sustainable Development"

United Nations "Report of the World Summit on Sustainable Development" (26 Aug-4 Sep 2002 Johannesburg) 1-166

United Nation "Earth Summit"

United Nation "Earth Summit" (3 June – 14 June 1992 Brazil)

UNSGAB *Nexus concept // The nexus approach vs IWRM – Gaining conceptual clarity*

UNSGAB *Nexus concept // The nexus approach vs IWRM – Gaining conceptual clarity* (2014) available at https://www.water-energy-food.org/news/nexus-concept-the-nexus-approach-vs-iwrm-gaining-conceptual-clarity accessed 21 November 2021.

Vallero "Thermal pollution"

Vallero D A "Thermal pollution" in Letcher T M and Vallero D A (eds) *Waste: A handbook for management* (Elsevier 2019) 381-404

Vezzoli "Energy and Sustainable Development"

Vezzoli C "Energy and Sustainable Development" in Vezzoli C *et al Designing sustainable energy for All* (Springer Cham 2018) 1-22

Viljoen "Critical perspectives on South Africa's groundwater law: established practice and the novel concept of public trusteeship"

Viljoen G "Critical perspectives on South Africa's groundwater law: established practice and the novel concept of public trusteeship" 2020 *Journal of Energy and Natural Resources Law* 1-18

Viljoen "South Africa's water crisis: The idea of property as both a cause and solution"

Viljoen G "South Africa's water crisis: The idea of property as both a cause and solution" 2017 *Law Democracy & Development* 176-200

Viljoen *Water as public property: a parallel evaluation of South African and German law*

Viljoen G *Water as public property: a parallel evaluation of South African and German law* (LLD-dissertation North West University 2016)

Villamayor-Tomas "The water-energy nexus in Europe and Spain"

Villamayor-Tomas S "The water-energy nexus in Europe and Spain" in Ziolkowska J R and Peterson J M (eds) *Competition for Water Resources* (Elsevier 2017) 105-118

Von Bormann *Understanding the Food Energy Water Nexus: Through the water and food lens*

Von Bormann T *Understanding the Food Energy Water Nexus: Through the water and food lens* (2014) available at http://www.fewlbnexus.uct.ac.za/sites/default/files/image_tool/images/91/few_through_the_water_and_food_lens.pdf accessed 7 March 2021

Von Uexkull *Energy and Water: The Ignored Link*

Von Uexkull O "Energy and Water: The Ignored Link" 2004 *Refocus* 40-44

Wackernagel, Hanscom, Jayasinghe, Lin, Murthy, Neill and Raven "The importance of resource security for poverty eradication" 2021 *Nature Sustainability* 731-738

Wackernagel M, Hanscom L, Jayasinghe P, Lin D, Murthy A, Neill E and Raven "The importance of resource security for poverty eradication" 2021 *Nature Sustainability* 731-738

Wang, Cao and Chen "Water-energy nexus in China's electric power system"
Wang S, Cao T and Chen B "Water-energy nexus in China's electric power system" 2017 *Energy Procedia* 3972-3977

Wang *Water-energy nexus: A critical review paper*
Wang R *Water-energy nexus: A critical review paper* (PhD-dissertation Yale School of Forestry and Environmental Studies 2017)

Wassung *Water scarcity and electricity generation in South Africa*
Wassung N *Water scarcity and electricity generation in South Africa* (Master of Philosophy University of Stellenbosch 2010)

Wiegleb and Bruns "What is driving the water-energy-food nexus? Discourses, knowledge and politics of an emerging resource governance concept"
Wiegleb V and Bruns A "What is driving the water-energy-food nexus? Discourses, knowledge and politics of an emerging resource governance concept" 2018 *Front. Environ. Sci.* 1-15

World Bank Group *How do water constraints affect energy planning in South Africa?*
World Bank Group *How do water constraints affect energy planning in South Africa?* (2017) available at https://openknowledge.worldbank.org/bitstream/handle/10986/26255/113464-WP-P144930-PUBLIC-W16014-eBook.pdf?sequence=5&isAllowed=y accessed 16 June 2021

World Bank Group *Modeling the water-energy nexus in China*
World Bank Group *Modeling the water-energy nexus in China* (2018) available at https://documents1.worldbank.org/curated/en/673891521756397998/pdf/124523-WP-P153716-public-21-3-2018-15-20-2-W.pdf accessed 16 June 2021

World Energy Council *World Energy Issues Monitor*
World Energy Council *World Energy Issues Monitor* (2017) available at https://www.worldenergy.org/assets/downloads/1.-World-Energy-Issues-Monitor-2017-Full-Report.pdf accessed 31 July 2021

World Wildlife Fund *Understanding the food energy water nexus: through the energy and water lens*

World Wildlife Fund *Understanding the food energy water nexus: through the energy and water lens* (2014) available at http://www.fewlbnexus.uct.ac.za/sites/default/files/image_tool/images/91/few_through_the_energy_and_water_lens.pdf accessed 8 October 2019

Yoon "A review on water-energy nexus and directions for future studies: from supply to demand end"

Yoon H "A review on water-energy nexus and directions for future studies: from supply to demand end" 2018 *Documents d'Anàlisi Geogràfica* 365-395

Zilberman, Sproul, Rajagopal, Sexton and Hellegers "Rising energy prices and the economics of water in agriculture"

Zilberman D, Sproul T, Rajagopal D, Sexton S and Hellegers P "Rising energy prices and the economics of water in agriculture" 2008 *Water Policy* 11-21

Zerilli "The rule of soft law: An introduction"

Zerilli F M "The rule of soft law: An introduction" 2010 *Journal of Global and Historical Anthropology 56* 3-18

### ***Case law***

Residents of Bon Vista Mansions v Southern Metropolitan Local Council 2002 (6) BCLR 625 (W)

*BP Southern Africa (Pty) Ltd v MEC for Agriculture, Conservation, Environment and Land Affairs* 2004 (5) SA124 (WLD)

*Earthlife Africa Johannesburg v the Minister of Environmental Affairs and Others* 2017 JOL 37526 (GP)

*Joseph and Others v City of Johannesburg and Others* 2010 4 SA 55 (CC)

*Mazibuko and Others v City of Johannesburg and Others* 2009 ZACC 28

*The Federation for Sustainable Environment and The Silobela Concerned Community v The Minister of Water Affairs and Others* (NGHC) (unreported) case number 35672/12 of 10 July 2012

***Legislation***

*Constitution of the Republic of South Africa*, 1996

*Electricity Act* 41 of 1987

*Electricity Regulation Act* 4 of 2006

*Eskom Conversion Act* 13 of 2001

*Municipal Systems Act* 32 of 2000

*National Climate Change Response White Paper*

*National Energy Act* 34 of 2008

*National Environmental Management Act* 107 of 1998

*National Environmental Management Biodiversity Act* 10 of 2004

*National Environmental Management: Waste Act* 59 of 2008

*National Energy Regulator Act* 40 of 2004

*National Heritage Resources Act* 25 of 1999

*National Water Act* 36 of 1998

*Mineral and Petroleum Resources Development Act* 28 of 2002

*Water Services Act* 108 of 1997

***International Instruments***

*Committee on Economic, Social, and Cultural Rights* General Comment No. 15 2003

***South African government publications***

GN 1360 in GG 42784 of 18 October 2019

GN R580 in GG 41689 of 8 June 2018

GN 710 in GG 31124 of 3 June 2008

GN R513 in GG 26169 of 14 May 2004

GN R509 in GG 22355 of 8 June 2001

The *National Development plan 2030: Our future – make it work*

***Internet sources***

African Union *Agenda 2063: The Africa we want*

African Union 2020 *Agenda 2063: The Africa we want* https://au.int/agenda2063/overview accessed 3 April 2021

Alexander *Cape Town's 'Day Zero' water crisis, one year later*

Alexander C 2019 *Cape Town's 'Day Zero' water crisis, one year later* https://www.bloomberg.com/news/articles/2019-04-12/looking-back-on-cape-town-s-drought-and-day-zero#:~:text=Labelled%20%E2%80%9CDay%20Zero%E2%80%9D%20by%20local,water%20splashed%20across%20news%20sites accessed 7 February 2021

Aqua tech *Sustainable water: Our essential guide to sustainable water resource management solutions and strategies*

Aqua tech *Sustainable water: Our essential guide to sustainable water resource management solutions and strategies* 2019 https://www.aquatechtrade.com/news/water-treatment/sustainable-water-essential-guide/ accessed 27 June 2021

Arcadia *How technology has influenced climate change both positively and negatively*

Arcadia 2020 *How technology has influenced climate change both positively and negatively* https://welcome.arcadia.com/energy-101/environmental-impact/how-technology-has-influenced-climate-change-both-positively-and-negatively/ accessed 10 June 2020

Arroyo *The water-energy nexus*

Arroyo 2010 *The water-energy nexus* https://www.circleofblue.org/wp-content/uploads/2010/08/Arroyo-2010-Water-Energy-Nexus.pdf accessed 6 April 2020

Biodiversity Disclosure Project *Biodiversity mainstreaming at Eskom*

Biodiversity Disclosure Project 2019 *Biodiversity mainstreaming at Eskom* http://www.bdprotocol.org/wp-content/uploads/2019/09/BDP_Eskom-Case-Study_210119.pdf accessed 29 October 2020

Brand South Africa *Drought SA: the gateway to managing water scarcity*

Brand South Africa 2015 *Drought SA: the gateway to managing water scarcity* https://www.brandsouthafrica.com/investments-immigration/science-technology/drought-sa-the-gateway-to-managing-water-scarcity?gclid=CjwKCAjwkdL6BRAREiwA-kiczAiENmvRqgqVch7LJm6ZHniQoy6P5fkZCxhF8KlipBEjAufkdllsrBoCxnsQAvD_BwE accessed 6 September 2020

Businesstech *Loadshedding in South Africa is inevitable: Ramaphosa*

Businesstech 2021 *Loadshedding in South Africa is inevitable: Ramaphosa* https://businesstech.co.za/news/energy/541566/load-shedding-in-south-africa-is-inevitable-ramaphosa/ accessed 28 November 2021

Caboz *It could take five years for Eskom's power stations to be fully up and running again – here's why*

Caboz J 2018 *It could take five years for Eskom's power stations to be fully up and running again – here's why* https://www.businessinsider.co.za/five-years-before-eskoms-broken-power-stations-are-up-and-running-again-heres-why-2018-12 accessed 7 February 2021

Carpenter *Water conservation in coal-fired power plants*

Carpenter A M 2017 *Water conservation in coal-fired power plants* https://www.usea.org/sites/default/files/Water%20conservation%20in%20coal%20fired%20power%20plants%20-%20ccc275.pdf accessed 6 May 2020

Centre for environmental rights *NGOs challenge Eskom's latest application to escape compliance with air pollution laws*

Centre for environmental rights 2020 *NGOs challenge Eskom's latest application to escape compliance with air pollution laws* https://cer.org.za/news/ngos-challenge-eskoms-latest-application-to-escape-compliance-with-air-pollution-laws accessed 10 September 2020

Centre for environmental rights *Water impacts and externalities of coal power*

Centre for environmental rights 2018 *Water impacts and externalities of coal power* https://cer.org.za/wp-content/uploads/2018/07/Water-Impacts-and-Externalities-Report_LAC.pdf accessed 1 June 2020

Centre for environmental rights *SA: Open letter to Ministers to ensure Eskom's compliance with obligations to protect environment and human health*

Centre for environmental rights 2016 *SA: Open letter to Ministers to ensure Eskom's compliance with obligations to protect environment and human health* https://www.polity.org.za/article/sa-open-letter-to-ministers-to-ensure-eskoms-compliance-with-obligations-to-protect-enviroment-and-human-health-2016-09-07 accessed 10 September 2020

Charles *Load shedding impacting food security*

Charles M 2019 *Load shedding impacting food security* https://www.iol.co.za/capeargus/news/loadshedding-impacting-food-security-20072945 accessed 21 May 2019

Cock *South Africa must end its coal habit. But it's at odds about when and how*

Cock J 2019 *South Africa must end its coal habit. But it's at odds about when and how* https://www.wits.ac.za/news/latest-news/opinion/2019/2019-03/south-africa-must-end-its-coal-habit-but-its-at-odds-about-when-and-how.html accessed 11 June 2020

Collins dictionary *definition of 'analytical'*

Collins dictionary *definition of 'analytical'* https://www.collinsdictionary.com/dictionary/english/analytical accessed 24 October 2021

Daniel *Winter load shedding is quickly approaching Eskom's worst-case scenario*

Daniel L 2021 *Winter load shedding is quickly approaching Eskom's worst-case scenario* https://www.businessinsider.co.za/eskom-load-shedding-worst-case-scenario-for-south-africa-2021-6#:~:text=The%20following%20month%2C%20South%20Africans,by%20Eskom's%20revised%20maintenance%20plans.&text=With%20a%20reduction%20in%20capacity,7%20billion accessed 24 June 2021

Department of Energy *National Energy Regulator of South Africa*

Department of Energy 2021 *National Energy Regulator of South Africa* http://www.energy.gov.za/files/esources/electricity/electricity_nersa.html#:~:text=NERSA%2C%20established%20in%20terms%20of,title%20to%20gas%20and%20petroleum.&text=It%20is%20also%20expected%20to,participation%20in%20the%20energy%20sector accessed 18 April 2021

Department of Mineral Resources *Coal Resources*

Department of Mineral Resources 2020 *Coal Resources* http://www.energy.gov.za/files/coal_frame.html accessed 6 September 2020

Department of Mineral Resources and Energy *Coal resources*

Department of Mineral Resources and Energy 2020 *Coal resources* http://www.energy.gov.za/files/coal_frame.html#:~:text=South%20Africa's%20indigenous%20energy%20resource,needs%20are%20provided%20by%20coal accessed 28 December 2020

Department of Water Affairs *National Water Resource Strategy 2*

Department of Water Affairs 2013 *National Water Resource Strategy 2* https://cer.org.za/wp-content/uploads/2013/07/NWRS2-Final-email-version.pdf accessed 11 February 2020

Department Water Affairs & Forestry *National Water Resource Strategy*

Department Water Affairs & Forestry 2004 *National Water Resource Strategy* https://cer.org.za/wp-content/uploads/2017/10/NWRS-2004.pdf accessed 21 September 2020

Department of Water Affairs *Department of Water Affairs clamps down on illegal water users*

Department of Water Affairs 2011 *Department of Water Affairs clamps down on illegal water users* https://www.gov.za/department-water-affairs-clamps-down-illegal-water-users accessed 5 July 2020

Department of Water Affairs *White Paper on a National Water Policy*

Department of Water Affairs 1997 *White Paper on a National Water Policy* https://www.gov.za/documents/national-water-policy-white-paper accessed 20 August 2020

Duignan *United Nation Conference on Environment and Development*

Duignan B 2020 *United Nation Conference on Environment and Development* https://www.britannica.com/event/United-Nations-Conference-on-Environment-and-Development accessed 4 October 2020

Earth Justice *Cleaning up power plant water pollution*

Earth Justice 2021 *Cleaning up power plant water pollution* https://earthjustice.org/cases/2014/cleaning-up-power-plant-water-pollution accessed 6 June 2021

Eskom Holdings Limited *Eskom and ash management*

Eskom Holdings Limited 2016 *Eskom and ash management* https://www.eskom.co.za/news/Pages/Feb20.aspx accessed 26 June 2021

Eskom Holdings Limited *Kusile power station project*

Eskom Holdings Limited 2020 *Cooling techniques at Eskom power stations* https://www.eskom.co.za/Whatweredoing/NewBuild/Pages/Kusile_Power_Station.aspx accessed 24 May 2021

Eskom Holdings Limited 2020 *Cooling techniques at Eskom power stations*

Eskom Holdings Limited 2020 *Cooling techniques at Eskom power stations* https://www.eskom.co.za/AboutElectricity/FactsFigures/CO%20%20Coal/CO%200005%20Cooling%20Techniques%20Rev%2013.pdf accessed 17 September 2020

Eskom Holding SOC Limited *Legislation*

Eskom Holding SOC Limited 2020 *Legislation* https://www.eskom.co.za/OurCompany/CompanyInformation/Pages/Legislation.aspx#:~:text=As%20a%20state%20owned%20enterprise,in%20the%20Public%20Sector%202002 accessed 4 October 2020

Eskom Holdings Limited *New research technology for water treatment and purification*

Eskom Holdings Limited 2016 *New research technology for water treatment and purification* https://www.eskom.co.za/news/Pages/Mar9.aspx accessed 26 June 2021

Eskom Holdings Limited Risk & Sustainability Division *Water reuse and recycle practises at Eskom power plants*

Eskom Holdings Limited Risk & Sustainability Division 2018 *Water reuse and recycle practises at Eskom power plants* https://www.eskom.co.za/AboutElectricity/FactsFigures/Documents/ENV/WaterRe-UseRecyclePowerPlants.pdf accessed 9 September 2020

Eskom Holdings Limited *Eskom Holdings SOC Limited Environmental Management Strategy*

Eskom Holdings Limited 2014 *Eskom Holdings SOC Limited Environmental Management Strategy* https://cer.org.za/wp-content/uploads/2018/05/Doc-1.3-a-Esk-env-strat-aug-14.pdf accessed 20 August 2020

Eskom Holdings Limited *Water Management*

Eskom Holdings Limited 2021 *Water Management* https://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/Reduction_In_Water_Consumption.aspx accessed 24 June 2021

Eskom Holdings Limited *Water Management*

Eskom Holdings Limited 2020 *Water Management* http://www.eskom.co.za/AboutElectricity/FactsFigures/Pages/Facts_Figures.aspx accessed 5 July 2020

Eskom Holdings Limited *Integrated Report 2012*

Eskom Holdings Limited 2012 *Integrated Report 2012* http://www.pads.eezeepage.co.za/i/69717-integrated-report-2012/9 accessed 10 September 2020

Eskom Holdings Limited *Fact Sheets – Security of water supply*

http://financialresults.co.za/2011/eskom_ar2011/fact_sheets_12.php

Eskom Holdings Limited 2011 Fact Sheets – *Security of water supply* http://financialresults.co.za/2011/eskom_ar2011/fact_sheets_12.php accessed 15 March 2019

Eskom *Electricity generation in South Africa*

Eskom 2016 Electricity generation in South Africa www.eskom.co.za/news/Pages/Nov2.aspx accessed 15 May 2019

Eskom *Water Management*

Eskom 2019 Water Management http://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/Reduction_In_Water_Consumption.aspx accessed 16 may 2019

Eskom *What is load shedding?*

Eskom 2019 *What is load shedding?* http://loadshedding.eskom.co.za/LoadShedding/Description accessed 15 May 2019

Food and Agriculture Organization of the United Nations *Water for Sustainable Food and Agriculture*

Food and Agriculture Organization of the United Nations 2017 *Water for Sustainable Food and Agriculture* http://www.fao.org/3/i7959e/i7959e.pdf accessed 6 June 2021

Fullerton *South African government supports fracking in the Karoo*

Fullerton K 2018 *South African government supports fracking in the Karoo* https://www.senseandsustainability.net/2018/08/28/south-african-government-supports-fracking-in-the-karoo/ accessed 28 December 2020

Generation Communication Department *Eskom Power Stations*

Generation Communication Department 2013 *Eskom Power Stations* http://www.eskom.co.za/Whatweredoing/ElectricityGeneration/PowerStations/Pages/Map_Of_Eskom_Power_Stations.aspx accessed 22 March 2019

Gladwin-Wood *Free Basic Electricity: do you have a right to it?*

Gladwin-Wood C 2016 *Free Basic Electricity: do you have a right to it?* http://www.schindlers.co.za/2016/free-basic-electricity-do-you-have-a-right-to-it/ accessed 22 March 2019

Global Energy Monitor *Water consumption from coal plants*

Global Energy Monitor 2021 *Water consumption from coal plants* https://www.gem.wiki/Water_consumption_from_coal_plants accessed 3 July 2021

Global Legal Insights *Energy*

Global Legal Insights 2020 *Energy* https://www.globallegalinsights.com/practice-areas/energy-laws-and-regulations/south-africa accessed 30 July 2020

Global Water Partnership *Dublin-Rion Principles*

Global Water Partnership 2020 *Dublin-Rio Principles* https://www.gwp.org/contentassets/05190d0c938f47d1b254d6606ec6bb04/dublin-rio-principles.pdf accessed 4 October 2020

Global Water Partnership *The need for an integrated approach*

Global Water Partnership 2020 *The need for an integrated approach* https://www.gwp.org/en/About/why/the-need-for-an-integrated-approach/ accessed 21 September 2020

Global Water Partnership *What is IWRM?*

Global Water Partnership 2011 *What is IWRM?* https://www.gwp.org/en/GWP-CEE/about/why/what-is-iwrm/ accessed 20 July 2020

Gurbo *Why are sustainable development goals important?*

Gurbo M 2017 *Why are sustainable development goals important?* https://idfi.ge/en/why_does_sdgs_matter accessed 22 March 2021

Hanania and Donev *Primary energy*

Hanania J and Donev J *Primary energy* 2020 available at https://energyeducation.ca/encyclopedia/Primary_energy accessed 9 June 2020

IOL *Eskom flouts environ laws*

IOL 2010 Eskom flouts environ laws https://www.iol.co.za/news/south-africa/western-cape/eskom-flouts-environ-laws-683802 accessed 10 September 2020

Jane and Ashton *Water Impacts and Externalities of Coal Power*

Jane R and Ashton M 2018 *Water Impacts and Externalities of Coal Power* https://cer.org.za/wp-content/uploads/2018/07/Water-Impacts-and-Externalities-Report_LAC.pdf accessed 17 March 2019

Joffe *Challenges for South Africa's Electricity Supply Industry*

Joffe H *Challenges for South Africa's Electricity Supply Industry* https://admin.hsf.org.za/publications/focus/focus-64/HJoffe64.pdf accessed 20 September 2020

Kaeding *Secondary Energy*

Kaeding N 2011 *Secondary Energy* accessed 9 June 2020

Karodia and Weston *South Africa's New Water Policy and Law*

Karodia H and Weston DR 2001 *South Africa's New Water Policy and Law* http://publications.iwmi.org/pdf/H029111.pdf accessed 20 August 2020

Lapping *The economic cost of South Africa's lockdown*

Lapping A 2020 *The economic cost of South Africa's lockdown* https://businesstech.co.za/news/business-opinion/396879/the-economic-cost-of-south-africas-lockdown/ accessed 5 July 2020

Malgas *SA water wastage red flagged*

Malgas N 2015 *SA water wastage red flagged* https://ewn.co.za/2015/08/03/Researchers-say-SA-could-reach-water-crisis-point#:~:text=Picture%3A%20Freeimages.com.&text=CAPE%20TOWN%20%2D%20A%20leading%20water,annually%20due%20to%20poor%20infrastructure.&text=Researchers%20said%20water%20leaks%20result,water%20being%20lost%20every%20day. Accessed 3 November 2019

Martin and Fischer *The energy-water nexus: energy demands on water resources*

Martin B and Fischer R 2012 *The energy-water nexus: energy demands on water resources* https://static1.squarespace.com/static/5a7859a10abd0477ecb31301/t/5c5d7f90eb393160e6d2d94c/1549631389713/water-energy-nexus_to+print.pdf accessed 5 February 2020

Mcsweeney and Timperley *The Carbon Brief profile: South Africa*

Mcsweeney R and Timperley J 2018 *The Carbon Brief profile: South Africa* https://www.carbonbrief.org/the-carbon-brief-profile-south-africa#:~:text=South%20Africa%20is%20the%20world's,a%20heavy%20reliance%20on%20coal. accessed 1 August 2020

Merriam-Webster *Essential meaning of 'discourse'*

Merriam-Webster 2021 *Essential meaning of 'discourse'* https://www.merriam-webster.com/dictionary/discourse

Mukoki *Load shedding having devastating impact on business - SACCI*

Mukoki A 2019 *Load shedding having devastating impact on business - SACCI* https://www.politicsweb.co.za/politics/load-shedding-having-devastating-impact-on-busines accessed 21 May 2019

Muller *South Africa needs good water management – not new water laws*

Muller M 2018 *South Africa needs good water management – not new water laws* https://theconversation.com/south-africa-needs-good-water-management-not-new-water-laws-91253 accessed 14 December 2020

Mytelka, Msimang and Perrot *Earth, wind and fire*

Mytelka L, Msimang V and Perrot R 2016 *Earth, wind and fire* https://www.sagreenfund.org.za/wordpress/wp-content/uploads/2016/04/MISTRA-RESEARCH-REPORT-Final.pdf accessed 8 October 2019

National Energy Technology Laboratory *Water usage in coal to power applications*
National Energy Technology Laboratory 2021 *Water usage in coal to power applications* https://www.netl.doe.gov/research/Coal/energy-systems/gasification/gasifipedia/water-usage accessed 3 July 2021

Power Technology *The Kusile power station project, South Africa*
Power Technology 2020 *The Kusile power station project, South Africa* https://www.power-technology.com/projects/kusilepowerstation/#:~:text=in%20March%202008.-,Kusile%20power%20station%2C%20which%20is%20expected%20to%20become%20the%20world's,gas%20desulphurisation%20(FGD)%20technology accessed 15 December 2020

Reig *What's the difference between water use and water consumption?*
Reig P 2013 *What's the difference between water use and water consumption?* https://www.wri.org/insights/whats-difference-between-water-use-and-water-consumption accessed 14 June 2021

Sguazzin *Eskom ordered to fix pollution issues at three power plants*
Sguazzin A 2020 *Eskom ordered to fix pollution issues at three power plants* https://www.bloomberg.com/news/articles/2020-11-12/eskom-ordered-to-rectify-pollution-issues-at-three-power-plants accessed 11 July 2021

Sguazzin and Naidoo *South Africa hit by power cuts even after maintenance boosted*
Sguazzin A and Naidoo P 2020 *South Africa hit by power cuts even after maintenance boosted* https://www.bloomberg.com/news/articles/2020-07-10/south-africa-hit-by-power-cuts-even-after-maintenance-boosted accessed 21 September 2020

South African Government *How do I access free basic municipal services?*
South African Government 2021 *How do I access free basic municipal services?* https://www.gov.za/faq/government-services/how-do-i-access-free-basic-municipal-services accessed 14 November 2021

Union of concerned scientists *Our energy choices: energy and water use*

Union of concerned scientists 2017 *Our energy choices: energy and water use* https://www.ucsusa.org/resources/energy-and-water-use accessed 24 May 2020

United Nations *Sustainable Development Goals 2030*

United Nations 2020 *Sustainable Development Goals 2030* https://www.un.org/sustainabledevelopment/sustainable-development-goals/ accessed 20 September 2020

United Nations *The Sustainable Development Agenda*

United Nations 2020 *The Sustainable Development Agenda* https://www.un.org/sustainabledevelopment/development-agenda-retired/#:~:text=On%201%20January%202016%2C%20the,Summit%20%E2%80%94%20officially%20came%20into%20force accessed 20 September 2020

U.S Department of Energy *The water-energy nexus: Challenges and opportunities*

U.S Department of Energy 2014 *The water-energy nexus: Challenges and opportunities* https://www.energy.gov/sites/default/files/2014/07/f17/Water%20Energy%20Nexus%20Executive%20Summary%20July%202014.pdf accessed 13 August 2021

Van Schie *Eskom's shocking environmental record*

Van Schie K 2012 *Eskom's shocking environmental record* https://www.iol.co.za/news/eskoms-shocking-environmental-record-1429715 accessed 11 July 2021

Walton *Energy has a role to play in achieving universal access to clean water and sanitation*

Walton M 2018 *Energy has a role to play in achieving universal access to clean water and sanitation* https://www.iea.org/commentaries/energy-has-a-role-to-play-in-achieving-universal-access-to-clean-water-and-sanitation accessed 6 May 2020

Winning *South African power generation plans keeps coal in the mix*

Winning A 2018 *South African power generation plans keeps coal in the mix* https://www.reuters.com/article/us-safrica-energy/south-african-power-generation-plan-keeps-coal-in-the-mix-idUSKBN1WX0OD accessed 1 June 2020

World Health Organization *Climate Change and Human Health*

World Health Organization 2005 *Climate Change and Human Health* https://www.who.int/globalchange/environment/en/ accessed 23 March 2019

World Health Organization *Millennium Development Goals (MDG's)*

World Health Organization 2018 *Millennium Development Goals (MDG's)* https://www.who.int/news-room/fact-sheets/detail/millennium-development-goals-(mdgs) accessed 22 March 2021

World Wildlife Fund *Water*

World Wildlife Fund 2021 *Water* https://www.wwf.org.za/our_work/water/ accessed 18 June 2021

Yelland *Eskom charged with serious environmental offences*

Yelland C 2020 *Eskom charged with serious environmental offences* https://citizen.co.za/news/south-africa/environment/2275700/eskom-charged-with-serious-environmental-offences/ accessed 10 September 2020