Afro Development Planning

The economic impacts of rolling blackouts in South Africa

Shaping the context

October 22, 2022

DOCUMENT TITLE	The economic impacts of rolling blackouts in South Africa
DOCUMENT TYPE	Discussion paper
HOW TO REFERENCE THIS DOCUMENT	Steenkamp, M. and Weaver, Z., 2022. The economic impact of rolling blackouts in South Africa: Shaping the context. Afro Development Planning. eThekwini, South Africa
AUTHORS	Marco Steenkamp and Zac Weaver
REVIEWER	Tasneem Steenkamp
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List of Abbreviations

BW	Bid Window
CCGT	Combined cycle gas turbine
CAPEX	Capital Expenditure
CI4P	Coal Independent Power Producer Procurement Programme
DoE	Department of Energy
DPE	Department of Public Enterprise
DMRE	Department of Mineral Resources and Energy
EIA	Environmental Impact Assessment
EIUG	Energy Intensive Users Group
GDP	Gross Domestic Produce
IPP	Independent Power Producer
IRP	Integrated Resource Plan
LNG	Liquid Natural Gas
MW	Megawatt
NDC	Nationally Determined Contributions
NDP	National Development Plan
NERSA	National Energy Regulator of South Africa
OCGT	Open Cycle Gas Turbine
PGM	Platinum Group Metals
PV	Photovoltaic
REI4P	Renewable Energy Independent Power Producer Procurement Programme
RMI4P	Risk Mitigation Independent Power Producer Procurement Programme
SMME	Small, micro, and medium-sized enterprises
ZAR	South African Rand

1. Introduction

1.1. Overview

This report forms part of the Environmental Impact Assessment (EIA) undertaken for the proposed gas-to-power Powership application at the Port of Saldanha Bay, Port of Richards Bay and Port of Ngqura (hereafter referred to as the Karpowership project). Afro Development Planning Pty Ltd (hereafter referred to as Afro) was appointed by Triplo4 Sustainable Solutions (Pty) Ltd (hereafter referred to as Triplo4), the lead Environmental Assessment Practitioners appointed by Karpowership SA (Pty) Ltd (hereafter referred to as Karpowership) to undertake the EIA.

Afro was appointed to compile a report to provide an economic perspective on the impact of loadshedding to the South African economy. Furthermore, to provide clarity with respect to the macro-economic context to which the EIA application has significant relevance.

This report does not, therefore, present results of macro-economic modelling of the economic impacts to the South African economy for instance, nor does it make any recommendations toward resolving the challenge of loadshedding. It merely serves to provide the economic- and energy context to which the EIA application has significant relevance and does so through a literature review.

This report presents the global energy landscape and current trends, the local energy context in which the Karpowership project has significant relevance, the economic challenges and impacts of loadshedding on the South African economy, and the various responses to loadshedding. This includes perspective on the Karpowership proposed project by setting the context for this proposed project and providing an explanation of the contribution that the Karpowership project makes towards the Risk Mitigation Independent Power Producer Programme.

1.2. Project background

The Risk Mitigation Independent Power Producer Procurement Programme (RMI4P) was initiated by the Department of Minerals Resources and Energy's (DMRE) in response to the culmination of a decade of loadshedding resulting in significant detrimental impacts on the South African economy. The electricity crisis is a function of numerous factors ranging from corruption and plant mismanagement, to delays in the independent power procurement programme deployment, but more so a result of unreliable baseload power. To address loadshedding within the next few years the current baseload capacity challenges needs to be addressed through, among others, replacing this with similar generation technologies, or dispatchable power plants which have the flexibility to address both baseload and load following needs. Few generation technologies are able to provide both consistent, and stable baseload power, as well as load following capabilities. Karpowership's floating power fleet is able to provide both, effectively.

In December 2020, Karpowership submitted a bid in response to the Department of Minerals Resources and Energy's (DMRE) Risk Mitigation Independent Power Producer Procurement Programme (RMI4P) request for proposals (DMRE, 2021a). Karpowership was subsequently awarded preferred bidder status on 18 March 2021, along with seven other bidders. Karpowership's bid provides 1220MW of the total 2000MW allocated through the RMI4P (i.e., 450MW in Coega, 450MW in Richards Bay and 320MW in Saldanha Bay) (Karpowership, 2021) for a contractual term of 20 years (IPP Office, 2021b).

Understandably, one company being awarded the majority of generation capacity of the RMI4P highlights the potential risk that the country faces should Karpowership be unable to deliver the required energy - especially given the urgent need to remedy the energy crisis in South Africa which has been precipitated by an ailing national utility, namely Eskom. While Karpowership is confident that it is extremely unlikely that it will fail to deliver on its contractual obligations, there are other externalities that may result in Karpowership being unable to deliver, e.g., legal processes, permitting and licensing requirements, sabotage, etc.

It is also important to note that in the long term, in achieving the energy mix as proposed by the Integrated Resource Plan (IRP) 2019 the contributions of gas-to-power projects are small. However, gas-to-power and particularly the Karpowership project has an important role to play in responding to the energy crisis.

Gas-to-power plants play a critical role in providing dispatchable electricity, which neither coal nor renewable energy can provide. This is important to understand as gas-to-power can provide stabilisation to the energy mix, and Karpowership more specifically, can provide baseload, mid-merit and peaking power. Furthermore, and given the role of gas-to-power in the energy mix it serves to enable and support the deployment of large-scale renewable energy, while still significantly reducing emissions by reducing the reliance on electricity produced by coal-fired plants.

In the South African context, and as presented in the IRP 2019 provision has been made for gas in the energy mix, this coupled with the urgent need to respond to the energy crisis makes it clear that due consideration is to be made for the Karpowership project. The Karpowership project has significant relevance given the following:

- The Karpowership fleet can be deployed immediately, and Karpowership project can reach commercial operation in 12 months given the infrastructural requirements on the landside. This allows for additional generation capacity coming online timeously, given the urgency to resolve loadshedding.
- Karpowership can provide baseload, mid-merit and peaking power and because Karpowership provides dispatchable power, it can respond in minutes when the energy supply is under strain.
- Given the nature of the RMI4P, and the associated purchase agreements, Karpowership will only generate electricity after being issued a dispatch instruction by the system operator. In other words, Karpowership will operate only when required to do so.

- The Karpowership project has a contract duration of 20-years and will therefore be a temporary power generator in the energy mix in South Africa.
- Because Karpowership is a floating power plant, there is little risk of stranded assets or lengthy decommissioning timeframes.
- The Karpowership project will create thousands of new jobs over the construction and operational phases of the project. During the operational phase the Karpowership will also contribute to skills and capacity development which will benefit locals and that contribute to South Africa's just transition.
- The Karpowership project will produce less than half the GHG emissions, and a fraction of the particulate emissions to that of coal. It is therefore expected to directly result in more emissions avoided (from coal-fired plants) than it will contribute to the global stock of greenhouse gas emission, and will have a positive climate change impact by supporting the deployment of renewable energy in the country (Promethium Carbon, 2022).
- The Powerships should not be considered a replacement of renewable energy, but rather a complementary technology to renewable energy, which supports the transition away from coal. A full transition to renewable energy will require a significant increase in battery manufacturing and deployment – a 44 times increase internationally by 2030 (IEA, 2022) is required to achieve renewable energy providing baseload. This significant increase in demand is highly likely to see developed, richer countries, out bidding and securing battery capacity ahead of developing countries. The Powerships provide a highly feasible alternative through its ability to provide rapidly dispatchable electricity which can make up any shortfalls in renewable energy's intermittent electricity production which might arise.
- Development of a gas industry in South Africa is already underway, and will continue, and thus the skills, supply, and enterprise development undertaken by Karpowership will further contribute to establishing a more efficient and viable domestic industry. This will ultimately lead to increased job creation activities.

These key points are discussed in detail in the subsequent chapters in the report and Appendix A. It is also worth mentioned upfront that that the power procurement under the RMI4P is significantly different to that of the Renewable Energy Independent Power Producer Procurement Programme (REI4P), and the wider development of the electricity generation in South Africa. The RMI4P seeks to address the current, and critical shortfall in electricity supply, which has resulted in South Africa's energy crisis. As such the procurement seeks to address the short-term deficit in electricity supply – rather than determining the future energy mix - and therefore the speed at which projects can come online after financial close is a critical consideration.

In other words, the objective of the RMI4P is to satisfy the short-term electricity supply gap, ease the current electricity supply constraints and reduce the wide-scale usage of diesel-based peaking electrical generators using alternative energy technologies (DMRE, 2021a). RMI4P is part of an attempt by government to procure a net increase of more than 23 900 megawatts (MW) of energy over the next eight years (i.e., short term) during which time, and as assumed in the IRP 2019, Eskom will decommission 8000 MW of power from its coal fleet (Futuregrowth, 2021).

2. Global energy landscape

Fossil fuels have, historically, been the mainstay of electricity generation (NS Energy, 2015; Ritchie et al., 2020). However, technological advancements in renewable energy (Roser, 2020), the climate crisis (Newburger, 2022), and recognition of the impact of fossil fuels on human health (Holland, 2017) among others, have resulted in a global shift away from fossil fuels towards alternative energy sources (WEO, 2021).

As of 2021 coal accounted for 36% of electricity generation globally, while gas accounted for 23%, nuclear accounted for 10%, oil for 3%, and all renewables combined accounted for 28% of electricity generation (Ritchie et al., 2020). This marks a decline of coal-fired power which peaked in 2007 when it accounted for 41% of global electricity generation capacity, and this decrease is predominately due to an increase in gas, and renewable energy sources (Ritchie et al., 2020). However, while coal-based electricity generation has decreased relative to other technologies, 2021 saw the highest amount of power generation from coal as economies began to recover from the strict lockdowns implemented to deal with the height of the COVID-19 pandemic (IEA, 2021).

The transition away from coal already hampered by COVID-19, has been further impacted by the Russian invasion of Ukraine which had resulted in significant price increases in oil and gas derived fuels. This in turn lead to a reduction in gas-based electricity generation in Europe and an increase in coal-fired generation (Tollefson, 2022). In the long-term, however, the invasion is likely to result in an acceleration of European transition towards renewable energy, with the European Commission committing to phase out Russian fossil fuel imports by the end of 2022, and accelerate the deployment of renewable energy resources (Council of the EU, 2022).

Germany has experienced one of the largest disruptions to its energy supply and compromise to its energy security, as it received more than half its natural gas from Russia (Eddy, 2022), while relaying significantly on renewable energy for intermittent supply. This has resulted in Germany delaying the decommissioning of two nuclear energy plants (Clifford, 2022). The transition away from Russian fossil fuels is likely to put a strain on international supplies of natural gas as Europe seeks new sources from countries such as the United States, Qatar, and Azerbaijan amongst others (Reed, 2022).

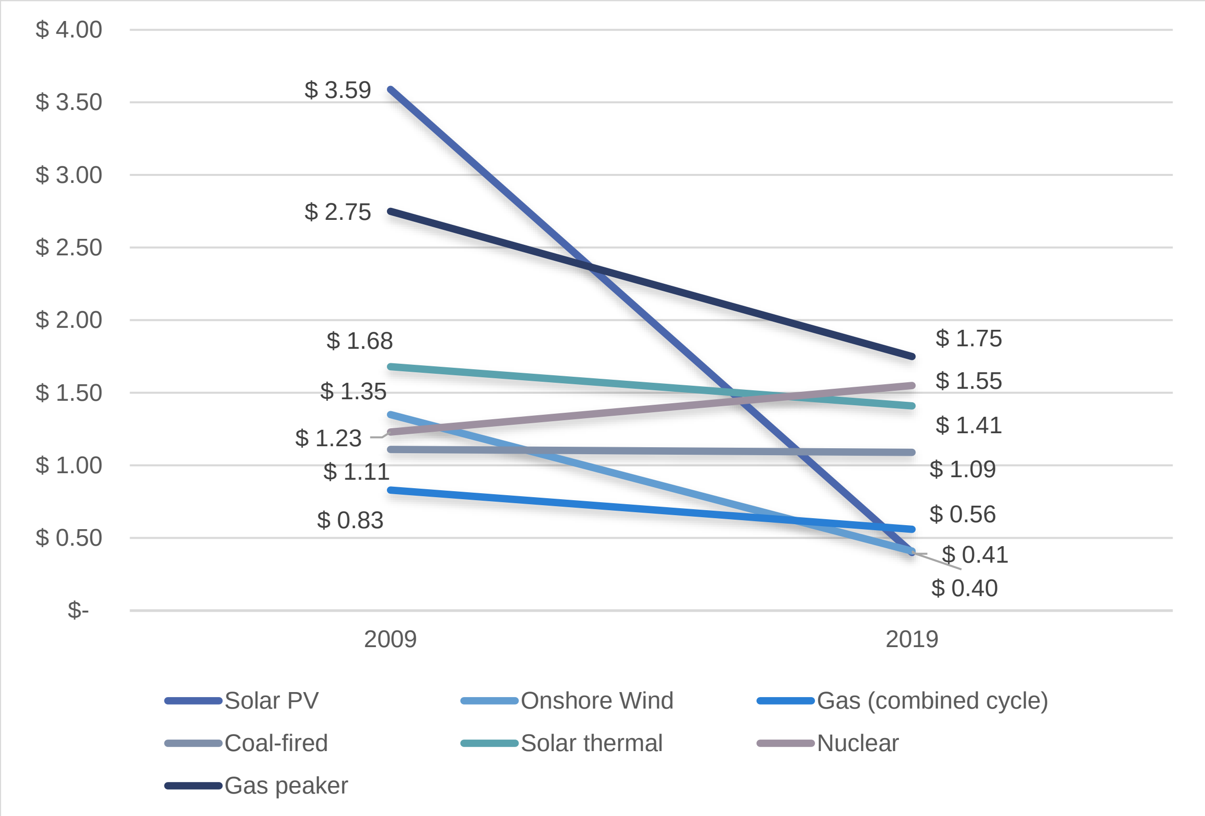
Beyond the COVID-19 pandemic and the Russian invasion of Ukraine, the global transition from coal has seen significant increases in gas-based generation (IEA, 2019). Gas based electricity generation results, on average, in 50% less CO_2 emissions than coal fired plants (Shuai et al., 2018). It is therefore an attractive alternative to coal during the transition to renewable energy - although this is context specific (Roff et al., 2022).

From a cost perspective gas combined electricity generation has historically been cheaper than coal, although gas peaking is more costly (Ray, 2020). Gas is, however, considered a bridging energy source, as it is still significantly more polluting during operations than renewable energy and subject to greater price fluctuations as exacerbated by the 2022 energy crisis precipitated by the Russian invasion of Ukraine. International climate agreements such as the Paris Agreement, and commitments made during COP26 (African Development Bank, 2021) have seen countries commit to shifting their energy mixes significantly towards renewable energy under their Nationally Determined Contributions (NDCs) (IRENA, 2020). The pace of transition is expected to increase steadily as renewable energy resources become cheaper – already producing electricity cheaper than coal (Ray, 2020) – and as battery storage technology improves. The cost reductions in renewable energy when compared to fossil fuel-based generation have been significant, with the most notable being the levelized costs of energy (LCOE) of onshore wind having decreased by 70% in the last 10 years, and the LCOE of solar photovoltaic (PV) having declined by 89% of the same period (Roser, 2020).

It should, however, be noted that while wind and utility scale solar PV have experienced significant declines in terms of LCOE, these industries have matured with the rate of decline having diminished (Lazard, 2021b). These significant changes as illustrated by Rosner's (2020) present a comparison of the cost of electricity from new power plants (see Figure 1). From Figure 1 it is evident that the cost of new coal plants has decreased by 2% only (between 2009 and 2019) and is approximately twice as costly as onshore wind and solar PV. Similarly, while combined cycle gas has decreased by 32%, it remains more expensive than both onshore wind and solar PV, and gas peaker plants even more so (Roser, 2020). These cost differences between renewable energy and fossil fuel-based electricity generation are significant, and are likely to increase over time as renewables become cheaper as the technology improves and greater economies of scale are developed in manufacturing (Adrian et al., 2022; Wood, 2021), however the levelized cost is only one dimension of the generation technologies.

When simply comparing the cost of fossil fuels to renewable energy, fossil fuels are significantly higher, but when accounting for the impact on human health (Vohra et al., 2021), the cost of coping with the impacts of the climate crisis, and the potential economic growth and job creation from switching to renewable energy (Wood, 2021), the gap between renewable energy and fossil fuels continues to grow. However, the impact of intermittent supply, especially in the South African context cannot be ignored, as the economic impact of loadshedding has been significant - as unpacked in the subsequent chapter. In other words, it's not a question of cost alone, but the generation technology's dispatchability in conjunction with the cost as energy security (among others) is crucial for economic activity to take place.

Figure 1 The price of electricity from new power plants



Source: Roser (2020)

Developing countries such as China and India have already made significant progress in transitioning from coal fired generation (The Times of India, 2017; United Nations Environment Programme, 2017; Varadhan, 2022) to developing renewable energy resources. China is one of the world's largest producers of solar and wind energy resources, and one of the largest investors in renewable energy (both locally and abroad) (Chiu, 2017). India similarly has made the transition to renewable energy a significant policy mandate, seeking to leverage the transition to increase energy security and as a means of driving economic growth through developing both electricity production and renewable energy resource manufacturing (Kumar J & Majid, 2020).

South America as a region has one of the largest shares of renewable energy in their regional energy mix with more than a quarter of energy coming from renewable sources in 2016, which is predominantly sourced from hydropower (IRENA, 2016), but with an increasing contribution from solar and wind energy (IRENA, 2019).

In summary, while the COVID-19 pandemic and the Russian invasion of Ukraine have increased dependence on coal in the past two years, the global energy mix is steadily shifting away from fossil fuel-based energy generation. This transition has three main driving factors: the significant reduction in the cost of renewable energy which has made fossil fuel-based electricity more expensive that renewable energy-based electric (Adrian et al., 2022; Wood, 2021); the recognition of the impact of fossil fuel emissions on human health (Vohra et al., 2021); and the existential threat of the climate crisis to humanity (Moseman & Setiya, 2021).

3. South African energy context

3.1. Generation capacity & associated costs

Reliable infrastructure - water, sanitation, energy and transport - are universally accepted to be crucial for facilitating progress toward raising the quality of life of people (Rentschler et al., 2019). Access to clean, reliable, and affordable energy is widely acknowledged as the foundation to addressing developmental needs especially in the developing world context and is fundamental to economic-growth and development. Understanding the challenges and impact of rolling blackouts in South Africa is fundamental to contextualising the appropriateness of generating electricity through various energy generation technologies. This is of relevance in a country where the national power utility, namely Eskom, has failed to deliver stable electricity for more than a decade.

Eskom is the national electricity generator, and system operator but also owns and operates the transmission and distribution networks with the exception of those owned and managed by the larger metros. Eskom sells electricity either directly to the consumer, or to the municipalities who then redistribute it to customers. For the financial year end March 2021, Eskom generated 191 852GWh from their 30 power stations with a capacity of 46 466MW (Eskom, 2021d). Despite this, Eskom also implemented 47 days of loadshedding over the same period (Eskom, 2021d), with loadshedding in 2022[1] already exceeding this (Bloomberg, 2022b).

Eskom's generation capacity is heavy dominated by coal-fired power (Eskom, 2021d), with the average age of the power stations (excluding Medupi and Kusile) being approximately 40 years (Bega, 2022; de Ruyter, 2021). Medupi and Kusile were both due for commercial operation by 2014, but the most recent update from Eskom, indicates that Medupi will only reach full project completion by November 2023, and Kusile by May 2026 – almost 20 years after construction started in 2007 (Labuschagne, 2022b).

For the decade prior to 2007, Eskom had successfully deployed reliable and affordable electricity to most South African citizens, primarily through its coal fired generation fleet. This was preceded by an impressive electrification campaign (the Integrated National Electrification Programme) which sought to address the inequalities of electricity access during apartheid (DMRE, 2019a), where prior to 1990 less than a third of the population had access to electricity (Marquard et al., 2007) to 84.4% in 2020 (World Bank, 2022). However, this is no longer the case, at least with respect to its reliability and cost efficiency. In the South African context, the failure to deliver stable electricity is a function of numerous factors including corruption, non-payment by citizens, public entities and private sector firms, demand

[1] Loadshedding was experienced by the authors numerous times while preparing this report

inelasticity, misallocation of resources, lack of infrastructure maintenance, a stagnation in the demand for electrical energy in South Africa since 2007, and the inflexible construction programme marred with delays and cost over-runs (i.e., Medupi and Kusile) (Department of Public Enterprises, 2019).

Prior to 2007, most South African citizen had not experienced rolling blackouts (or loadshedding) (Maune, 2019), or realised how it would affect their daily lives. More than a decade later, South Africa still experiences loadshedding. South Africa residents experienced loadshedding for 47 days[2] between 01 April 2020 and 31 March 2021, at an estimated cost of R942m per day[3] to the South African economy (Eskom, 2021d). However, for 2022 thus far[4], South Africa has already been loadshed 46 days - a strong indicator that it’s more than likely to exceed the prior year’s (Labuschagne, 2022a).

Furthermore, over the last decade the price of electricity generated by Eskom increased by more than 350% (Moolman, 2017). The increase in electricity tariff is a direct result of Eskom’s capital expansion programme, driven almost exclusively by the construction of Kusile and Medupi and to a lesser extent, the Ingula pump storage scheme. The most recent combined estimate for Medupi and Kusile is estimated at R451bn[5][6][7], and the construction of Kusile, will continue to create upward pressure on Eskom’s cost of producing electricity, at least in the short term. Eskom’s rising electricity prices, of a heavily dominated coal-fired fleet also need to be viewed in the context of the global trend of declining prices of providing electricity using renewable energy resources (Taylor, 2018). These significant price increases, which as shown by Figure 2 and by Figure 3, have been higher than annual inflation since 2005 (excluding 2007), and have been, in part, used to meet the increasing costs of Eskom maintaining their aging coal fleet (NERSA, 2021).

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[2] Almost one day per week on average

[3] At stage 4 (4 000MW)

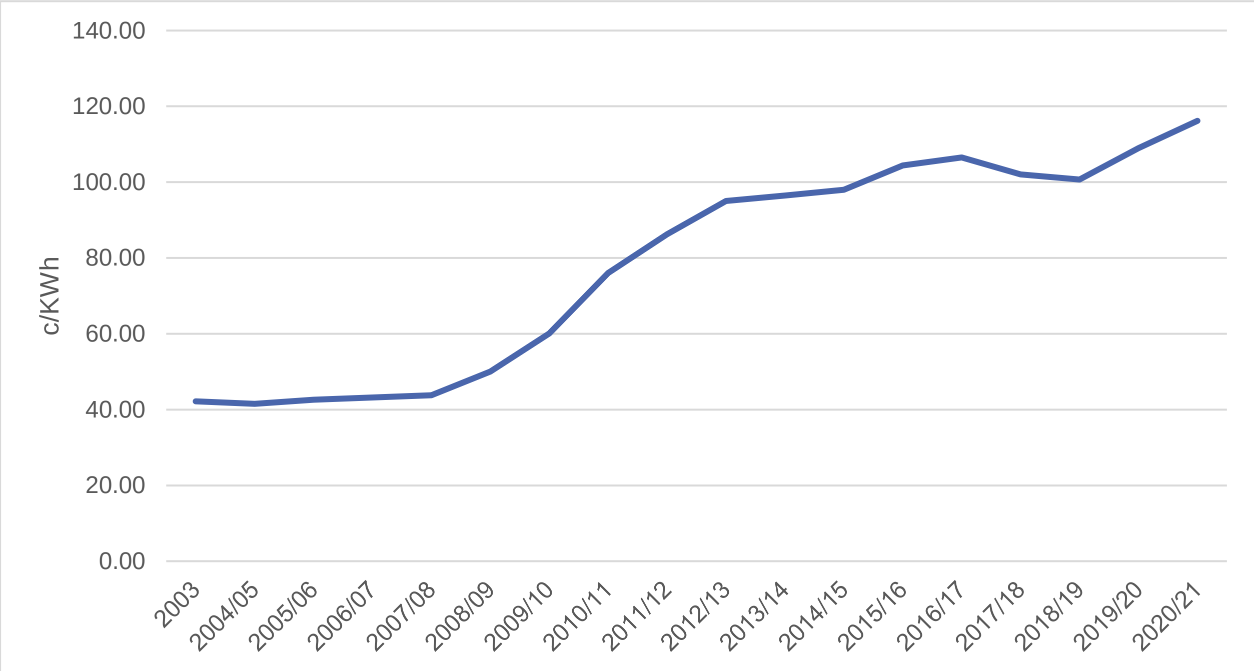
[4] 12 July 2022

[5] This includes the cost of interest during construction and cost associated with ensuring environmental; standards are met

[6] Although Medupi is complete, it is R154bn over initial budget of R80bn (MyBroadBand, 2021)

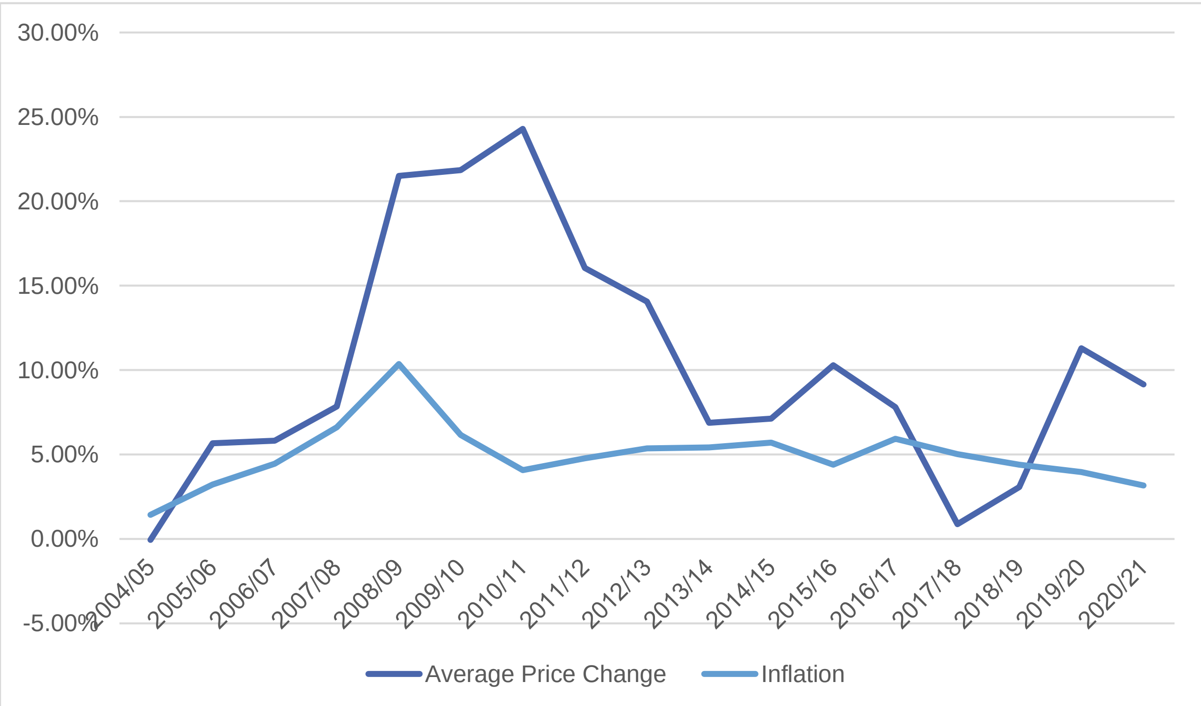
[7] The budget for Kusile is R161.4bn, excluding interest during construction (Madubela, 2021)

Figure 2 Eskom average[8] electricity tariffs adjusted to 2022 rands



Source: Eskom (2022b)

Figure 3 Comparison of average electricity price increase[9] and average price increase for South Africa



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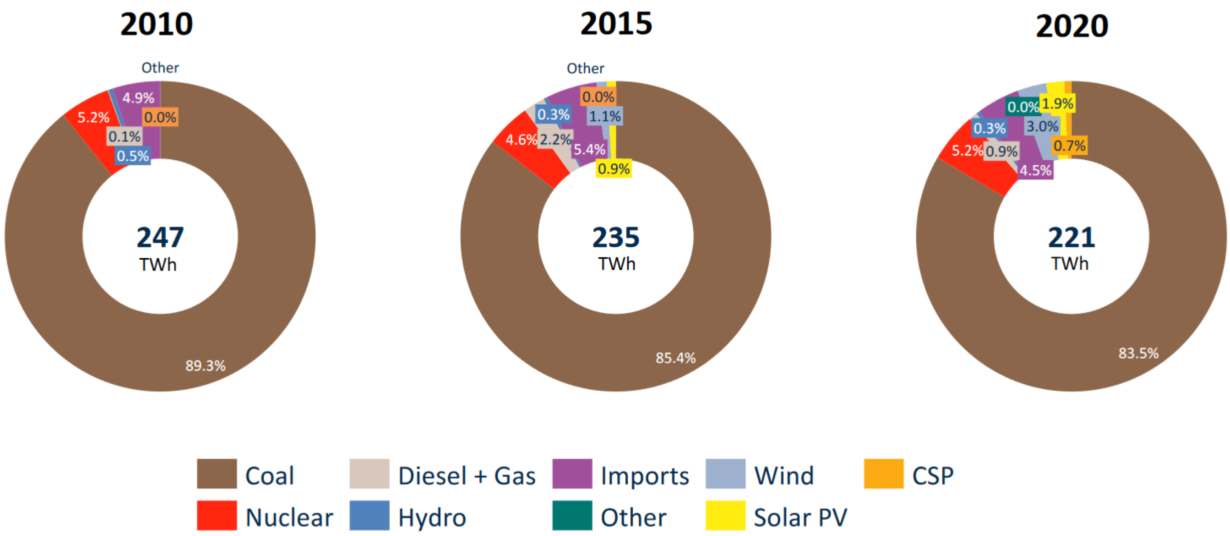
[8] Average tariff is calculated by Eskom as a simple average of the tariffs for all customers

[9] Average tariff is calculated by Eskom as a simple average of the tariffs for all customers

Source: Eskom (2022b) and Statistics South Africa (2022b)

As alluded to above, South Africa's energy mix is dominated by coal, accounting for 83.5% of electricity generation, followed by combined renewable energy contributing 10.5%, nuclear providing 5.5%, and the remaining imported or sourced from other sources as of 2020 (Calitz & Wright, 2020). This is despite South Africa having the world's third highest solar and wind energy density (Jain & Jain, 2017). This energy mix places South Africa as the 12th largest emitter of greenhouse gases in the world (Africa Check, 2021). The energy mix as of 2020 illustrated in Figure 4, clearly illustrates the decrease in South Africa's electricity supply.

Figure 4 Generation share from primary supply sources in 2010, 2015 and 2020 in South Africa



Source: Calitz & Wright (2020)

The reduction in Eskom's electricity supply has been driven by an aging coal-fired fleet, and decommissioning of old coal-fired plants, that will account for a 33 364MW reduction in capacity by 2030 (DMRE, 2019b). This aging coal fleet has put significant pressure on Eskom's ability to provide consistent electricity, and in late September 2022 roughly 21 878MW (BusinessTech, 2022d) of Eskom's total 46 466MW (Eskom, 2021a) was offline due to maintenance issues, meaning that only 53% of Eskom's generation capacity was available. This has forced Eskom to increasingly rely on OCGT, which is significantly more costly than coal for instance, and as of the 18th of September 2022 already cost Eskom R7.7bn for its financial year-to-date (Fin24, 2022).

Beyond planned shutdowns, disruptions to the electricity supply have been driven by a number of factors such as: industrial action by striking workers leading to plant shutdowns (Bloomberg, 2022a), wet coal leading to generation disruptions (Modise, 2022), governance issues with the supply of coal due to improper tenders resulting in poor quality and insufficient coal being delivered to plants (National Treasury, 2018), and most recently improper maintenance of various plants – including Kusile and Medupi – leading to unplanned shutdowns (Omarjee, 2022; Stoltz, 2022). These systemic issues in

Eskom's operations have resulted in persistent disruptions to the supply of electricity in South Africa since 2007, which have significantly hampered economic growth and development.

Recent statistics indicate that there was 1 169 hours of loadshedding recorded in 2021, which placed a huge strain on South Africa's economy (Creamer, 2022a), notwithstanding the impact of COVID-19. PWC estimates that loadshedding in 2021 resulted in up to a 3.1 percentage point decrease in Gross Domestic Product (GDP) growth, costing the economy up to 400 000 potential jobs (BusinessTech, 2022a). In an article by BusinessTech (2022b), chief economist at Alexforbes estimates that the stage 6 loadshedding in mid-2022, costs South Africa approximately R4bn in GDP a day.

Coupled with steadily increasing electricity tariffs which have significantly outpaced inflation (Labuschagne, 2020; Moolman, 2017), Eskom's inflexible construction programme marred with delays and cost over-runs (partly driven by design flaws see: Labuschange (2022b)), and previous delays in Eskom signing power purchase agreements with new independent power producers (IPPs) (Moyo, 2016) and more recently the delays in achieving financial close (Mavuso, 2022), South Africa's electricity crisis is set to continue. Beyond the issues listed above, there have been two additional drivers of the South African energy crisis, namely the delay of new IPP deals i.e., the Renewable Energy Independent Power Producer Programme (REI4P) and RMI4P – and Eskom's continued monopoly in the electricity market leading to inadequate and mismanaged supply.

3.2. Roll out of Independent Power Producers Procurement Programme

The REI4P was first introduced with Bid Window (BW) 1 (in 2011) which entered into agreements in 2012 (Pinto, 2021), and has had five subsequent BWs, with a total of 5 661 MW of capacity produced by 85 IPPs by December 2021, and with a total of 92 IPPs and 6232MW of energy contracted (IPP Office, 2021a). BWs 1 through 4 have contributed significantly to the South African economy, through R209.6bn in investment and creating 63 291 job years[10] over the construction and operation period of renewable plants built to date, while also helping to alleviate the shortages in Eskom's energy supply (IPP Office, 2021a).

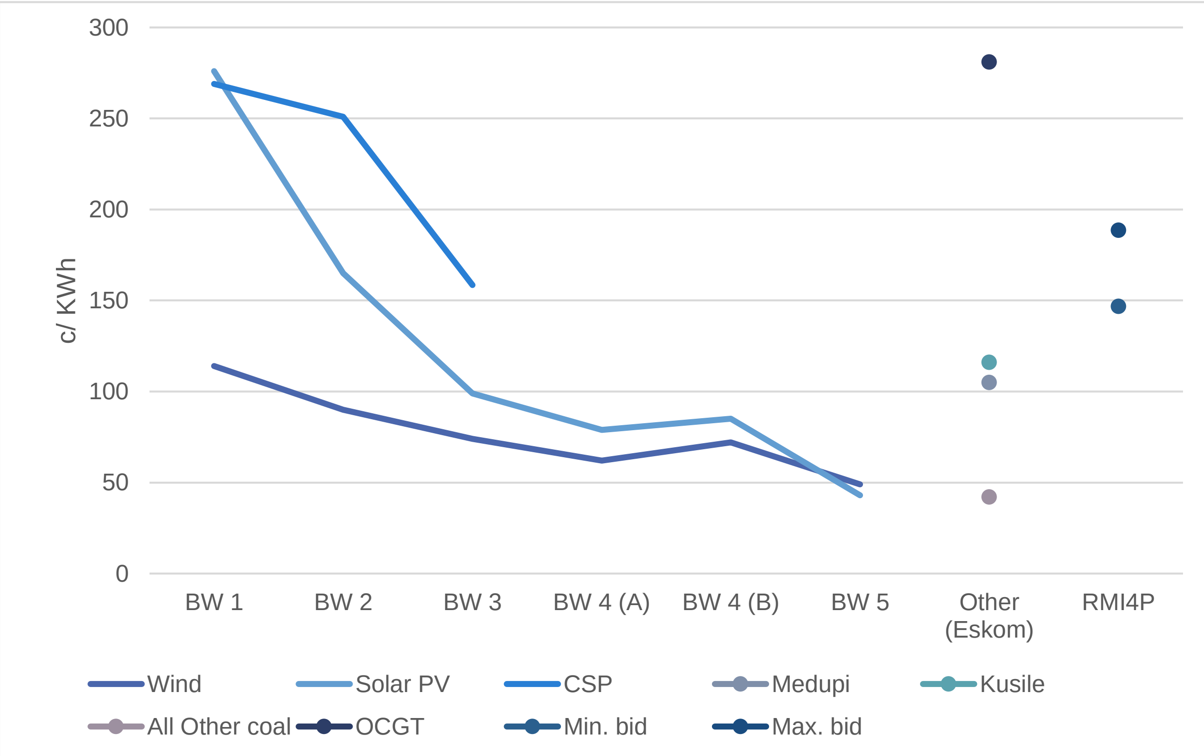
One of the reasons for lower than planned renewable energy capacity is a result of Eskom delaying the signing of power purchase agreements with 26 bids from BW4 IPPs, despite their approval under the REI4P, NERSA, and the then DoE (Omarjee, 2018). The resultant shortfall in production due to said delays and subsequent BWs has contributed significantly to recent loadshedding (Mgoduso et al., 2022). In an attempt to address the shortfall in electricity supply (and therefore loadshedding), BW 5 was announced and swiftly implemented in 2021 (with agreements being finalised in 2022), the opening and doubling of the generation capacity of BW 6 (IPPPP, 2022), the lifting of the 100 MW cap of private

[10] The equivalent of a full-time employment opportunity for one person for one year

distributed generation plants (Creamer, 2022c), and the announcement of the RMI4P in a bid to address the energy crisis.

Dispatchable power is critical for stabilising the supply of electricity, as Eskom's current generation capacity is unable to service the demand. This necessitates an expansion and continuation of the IPP programmes, which beyond increasing the energy supply will likely result in significant cost savings to the consumer, and public purse. This as electricity generation costs in South Africa have followed global trends with decreasing cost of renewable energy, which has already demonstrated renewable energy plants producing electricity at a lower cost than coal-fired and gas plants in South Africa (Eberhard & Naude, 2016). This cost comparison, although not perfect, is illustrated by Figure 5 (in 2022 ZAR terms), which illustrates that the cost of renewables over the five BWs has decreased to the extent that it is competitive with existing coal-fired power on a c/kWh basis. It is important to note that the values quoted by Eskom for their coal generation (all other coal, Kusile, and Medupi) costs is simply the cost of the primary energy, and does not account for maintenance or capital costs, and is likely far higher than presented (Planting, 2021). Similarly, what is important to understand is that the c/kWh cost of the BWs is *not* the cost of the service itself, as it does not account for the transmission and distribution costs (for instance, phase shifting, system balancing, voltage control, capacitive and inductive effects, dispatched ramping etc.). However, the RMI4P tariffs do reflect dispatchability, voltage stability and storage cost. Figure 5 illustrates a stark contrast between the various energy generation technologies on a c/kWh basis.

Figure 5 Comparison of IPPs, and Eskom's coal generation



Source: Creamer (2021a), Crown Publications (2021), Eberhard & Naude (2016) and Eskom (2021d)

3.3. Unbundling of Eskom

Finally, to appreciate the South African energy context, it is critical to examine the issues pertaining to Eskom's monopoly on electricity- generation, transmission, and distribution. While Eskom's monopoly predates a democratic South Africa, the 1998 White Paper on the Energy Policy of the Republic of South Africa, outlined the need to unbundle Eskom and transform it into a modern electricity utility and create opportunities for IPPs and alternate sources of energy. This in an effort to reduce fossil fuel pollution, and to address the shortfall in electricity supply which was anticipated to commence in 2007 (PARI, 2013).

This articulated that unbundling of Eskom would involve the creation of separate legal entities for the *generation, transmission, and distribution* divisions of Eskom which would operate separately from each other (PARI, 2013).This process became mired with issues in the early 2000s, and terminated due to issues raised by several stakeholders and resistance from Eskom itself (PARI, 2013). However, as Eskom's financial stability unravelled from 2007 onwards (Amra & Mnguni, 2017) the need for their unbundling became clear, if they were to address their financial challenges, and create opportunities for the IPPs (National Treasury, 2019). The unbundling process was reinitiated by president Cyril Ramaphosa (Merten, 2020), and encouraged by the National Treasury in their *Towards and Economic Strategy for South Africa* report (National Treasury, 2019). As of December 2021 a merger agreement was signed to transfer Eskom's Transmission division to its subsidiary National Transmission Company of South Africa (Eskom, 2022c), with *generation* and *distribution* planned to be formed by the end of 2022 (ESI Africa, 2022).

The unbundling[11] of Eskom will allow for a significant change in the energy landscape of South Africa, as it will both allow for rapid modernisation of electricity provision and create competition in energy generation. Unbundling will likely remove historic barriers to transitioning towards decarbonisation and allow greater competition in the electricity market which would reduce the ability for rent seeking (Van der Nest, 2015) and therefore reduce the cost of electricity to the customer.

4. Economic impacts of rolling blackouts in South Africa

4.1. Introduction

While most individuals would agree that loadshedding negatively impacts their daily lives, the extent of and accumulative impacts of loadshedding are often highlighted in the media but seldom unpacked given the complexity of accurately quantifying these impacts. In this chapter we aim to answer: What are the economic impacts of rolling blackouts (or loadshedding) in South Africa? Or put differently, *loadshedding is bad, but how bad is it really?* This question is tackled by presenting the economic

[11] The estimated cost of unbundling Eskom is R500m (Parliamentary Monitoring Group, 2021)

impact of loadshedding to the individual, big business (incl. energy intensive users), small, micro and medium enterprises (SMMEs), and investors relative to the direct, indirect, and macro-economic impacts to these groups. Similarly, the coping cost will briefly be discussed. Thereafter, the response to the energy crisis, by Eskom, government, and the customer, is discussed.

4.2. Challenges and economic impacts

It is worth acknowledging upfront that the impact of loadshedding is not felt equally by all firms and individuals, but it *is* felt by all to some extent. The extent of the impact of loadshedding on firms is a function of a number of factors including, the sector within which said firm operates, the geographic location of the firm itself and its operations, and the ownership structure (i.e., state owned, domestic owned or foreign owned), etc (Rentschler et al., 2019). Similarly, the extent of loadshedding at a country level would be a function of electrification, population density and urbanisation for instance. These factors, amongst other contextual variables, have a bearing on the extent of adverse effects of loadshedding on the South African economy. Moreover, a lack of electricity impedes and lowers the quality of service delivery such as health care, education, and other public services (Blimpo & Cosgrove-Davies, 2019).

The impacts of loadshedding can be categorised as follows:

- Direct impacts are those which are most visible, for example a firm relying on electricity to power the machines required for operating.
- Indirect impacts are those related to the cost of coping with unreliable power supply.
- Coping costs are those costs incurred to mitigate the impact of loadshedding on operations.
- The macro-economic & long term-impacts, are the cumulative impact of persistent and on-going loadshedding.

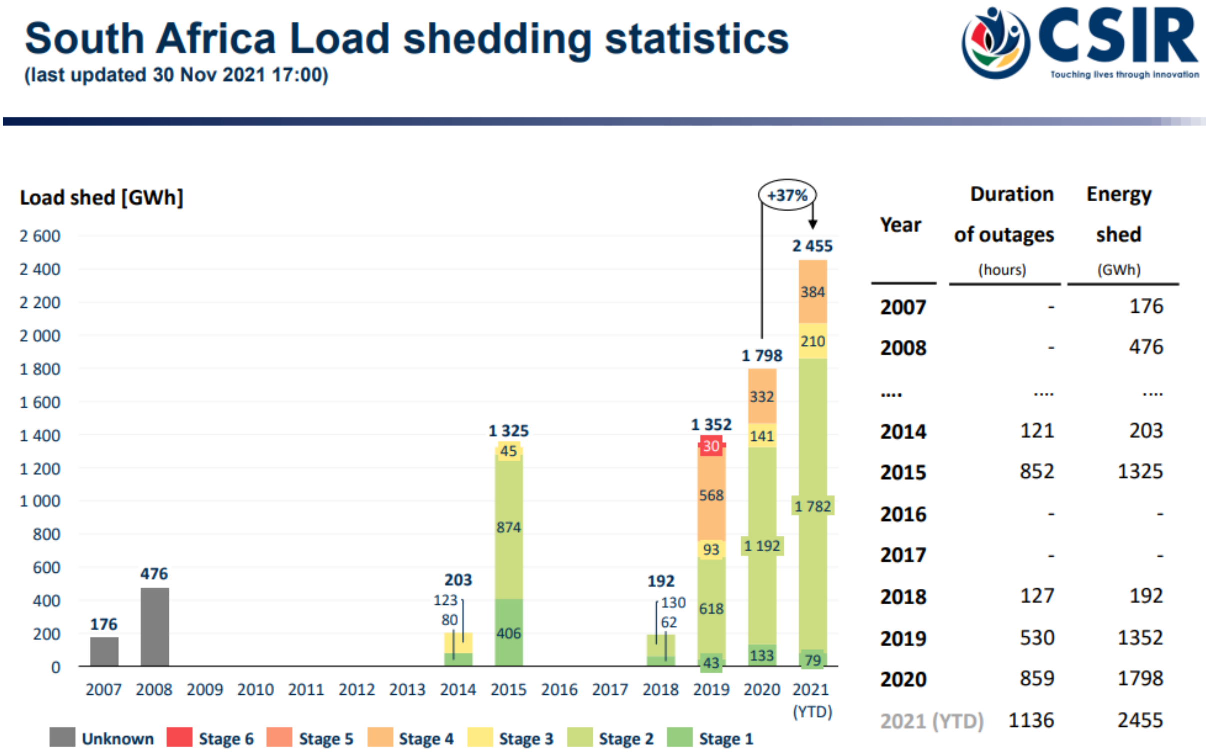
Other considerations that are acknowledged but not covered in this report in detail are, the differing impacts of loadshedding as a result of planned vs unplanned power supply interruptions, the timing of interruptions (i.e., time of day, week, season), and the frequency and duration thereof.

It is worth further acknowledging that South Africa is considered an upper-middle income country (World Bank, 2020), has both very high inequality, but also high human development (2018; UNDP, 2020; World Bank, 2020). South Africa, until 2012, was also considered the largest economy in Sub-Saharan Africa in terms of GDP (World Bank, 2021). However, the country is riddled with economic challenges, including growing unemployment, stagnant economic growth (macrotrends, 2022a), ballooning public debt (Statista, 2022b) and fiscal constraints, and corruption (Foley & Swilling, 2018). South Africa has been struggling to achieve, at the very least, economic growth experienced in the mid-2000s (macrotrends, 2022a). One of the culprits to stifling economic growth is loadshedding.

Loadshedding has had a significant impact on the South African economy, impacting the largest energy consumers such as mines and manufactures, to SMMEs, increasing the risk for both international- and local investors, and impacting consumer sentiments. As noted above, it is estimated that every day of

Level 6 loadshedding in 2022 costs the South African economy R4bn (BusinessTech, 2022b), while loadshedding in 2021 is estimated to have resulted in up to a 3.1% decrease in GDP growth, eliminating the opportunity for up to 400 000 potential jobs to be created (BusinessTech, 2022a). The Council for Scientific and Industrial Research (CSIR), found that 2021 was the worst year of loadshedding at the time with a 37% increase in electricity unserved relative to 2020, with a total of 2 455GWh of generation lost, and an estimated cost of unserved energy amounting to R215bn (CSIR, 2021), as illustrated by Figure 6.

Figure 6 Total Number of GWh Shed per Year in South Africa



Year	Duration of outages (hours)	Energy shed (GWh)
2007	-	176
2008	-	476
....	....	....
2014	121	203
2015	852	1325
2016	-	-
2017	-	-
2018	127	192
2019	530	1352
2020	859	1798
2021 (YTD)	1136	2455

Notes: Load shedding assumed to have taken place for the full hours in which it was implemented. Practically, load shedding (and the Stage) may occassionally change/ end during a particular hour; Total GWh calculated assuming Stage 1 = 1 000 MW, Stage 2 = 2 000 MW, Stage 3 = 3 000 MW, Stage 4 = 4 000 MW, Stage 5 = 5 000 MW, Stage 6 = 6 000 MW; Cost to the economy of load shedding is estimated using COUE (cost of unserved energy) = 87.50 R/kWh
Sources: Eskom Twitter account; Eskom Hld SOC Ltd FaceBook page; Eskom se Push (mobile app); Nersa; CSIR analysis

Source: CSIR (2021)

Loadshedding has added additional strain on economic growth, and further hindering the economic recovery after significant economic contractions experienced during the height of the COVID-19 pandemic (Statistics South Africa, 2022a). This impact on economic recovery is set to continue, given that as of the 14th of September 2022, 38% of 2022 had loadshedding (Whitfield, 2022), and Eskom expects at least level 2 of loadshedding to continue intermittently for the remainder of 2022 (BusinessTech, 2022d). Furthermore, and considering that: 1) the energy demand gap is likely to widen over the next five to eight years, as old coal-fired plants are decommissioned, coupled with the 2) likely increased operational challenges with the older coal-fired power stations, and 3) due to the delay in new builds relative to the timing presented in the IRP 2019 outlook, it is likely that loadshedding will continue until 2025 and possibly until 2030, with at least stages two to seven and possibly higher (Cruise, 2022; Davis, 2021).

This needs to be viewed in the context of Eskom's current decommissioning schedule, where a total of 8087MW of generation capacity will be decommissioned by 2030 (DMRE, 2019b). This will be offset by commissioning of energy from IPPs (REI4P BW5 - 2600MW (DMRE, 2021b), BW 6 - 4200MW (IPP Office, 2022), and RMI4P - 2000MW (IPP Office, 2021b)) totalling 88000MW. While in terms of capacity there is a marginal difference between what is decommissioned and what is commissioned, it is important to understand that baseload is being replaced by intermittent capacity through the REI4P BW. Which is likely to only partly supply the required energy, and therefore not resolve the generation constraint which requires dispatchable power.

However, the breakdowns (resulting in unscheduled maintenance) at Eskom's coal fired plants which are driving the September 2022 loadshedding are happening at both Eskom's old and newer plants – including its newest Kusile and Medupi (BusinessTech, 2022f; Stoltz, 2022). In other words, the increase of 713MW[12] is still short of the 1000MW shed under Stage 1 loadshedding and is therefore ineffective in creating sufficient capacity to compensate for breakdowns at Eskom's plants. Loadshedding has been driven by skill shortages (Paton, 2022), and maintenance issues (BusinessTech, 2022c), which indicates that such issues are likely to continue given that the time needed to attract and train new professionals to address Eskom's skill shortages (Paton, 2022) and change the maintenance practices are lengthy (BusinessTech, 2022c).

Mabugu and Inglesi-Lotz (2022) demonstrate empirically a positive relationship between a surplus of electricity and positive economic growth in South Africa. However, they further found that increases in electricity consumption is predicated on the excess supply of electricity in the South African economy (Mabugu & Inglesi-Lotz, 2022). This implies that the current energy crisis – which is characterised by a shortage of (baseload) energy supply, relative to demand - will result in a reduction in economic growth because businesses will be reluctant to expand operations, and their electricity consumption, under the threat of continued loadshedding. This has significant implications for economic growth in the short-term, as continued loadshedding is not only resulting in GDP loss but slows economic recovery even after loadshedding stops if an electricity surplus is not attained, when businesses are not shown clear evidence that loadshedding will not return.

Studies conducted across 23 African countries found that a 1% increase in the frequency of power outages results in up to a 3.3% decrease in firms output (Rentschler et al., 2019). These impacts are felt more significantly by small firms (Alby et al., 2013), as large firms tend to be better equipped to withstand electricity disruptions due to their ability to invest in back-up generation and due to their improved ability to cope with reduced sales and revenue attributed to interrupted production or service

[12] i.e., the difference between REI4P BW5-6 plus RMI4P and Eskom's capacity of decommissioned plants

provision (Rentschler et al., 2019). This results in reduced competition in the market, and therefore an increase in prices, and depending on the product or service, the reduction in demand can be minimal, or significant. This reduction in demand, and therefore a reduction in sales places pressure on businesses to manage their cost, with labour often being reduced as a cost cutting measure. This inevitably leads to reduced employment (Mensah, 2018).

Electricity disruptions further hamper long-term business planning, as they force firms to invest in costly back-up generation and other coping costs (see Table 1). This is done to support the continuation of current production levels and diverting funds away from investments into expanding production or services (Rentschler et al., 2019). This is essentially the opportunity cost of alternative investment.

Mining, manufacturing - including the concrete and steel industry which are important critical for infrastructure development - and large scale commercial agriculture, as represented by the Energy Intensive Users Group (EIUG) make up a significant portion of the South African economy, contributing over 22% to GDP and accounting for 40% of the electricity bought from Eskom (EIUG, 2020). By firm type, firms in the manufacturing – particularly those fabricating metal products or refining minerals – and mining tend to be more vulnerable to electricity disruptions (Rentschler et al., 2019). Loadshedding significantly impacts this group of businesses, which has resulted in a reduction of operations and significant retrenchments, with some big businesses closing down South African operations (EIUG, 2020).

Firms are less likely to upgrade machinery to more productive technologies under the threat of blackouts, which overtime can reduce the economy's ability to remain internationally competitive, and generate wealth (Rentschler et al., 2019). Loadshedding causes significant disruptions to mining operations, forcing several hour delays as miners exit mines, while smelters and refineries are unable to run given that they need a constant supply of electricity to operate (Van der Nest, 2015). The significance of exporting precious metals and other mining products to the South African economy means that power disruptions can result in a depreciation of the local currency (i.e., the ZAR), increasing the cost of imports and the cost of doing business internationally (Van der Nest, 2015).

It is also important to consider the impact of loadshedding more specifically on the platinum group metals (PGMs) industry in South Africa, given its importance in the global transition to clean energy, and its role in South Africa's Hydrogen Roadmap for South Africa (Department of Science and Innovation, 2021). South Africa holds 94% of the world's PGM metals (Minerals Council South Africa, 2019), which are critical for the transition to a green economy. Platinum is used in catalytic converters which in turn is used to produce hydrogen which is anticipated to be the *fuel of the future*, essentially replacing fossil fuels as one of the primary fuels for transport with the capability of producing zero harmful emissions (Metcalfe et al., 2020).

The PGMs industry is capable of coping, albeit with minimal challenges, with loadshedding levels 1 through 3, however stage 4 loadshedding significantly reduces output, and at stages 6 or above operations would cease (Davis, 2021). Of Eskom's total supply of electricity, 14% is used by the mining industry (Eskom, 2021d), with the platinum mining industry using 40% of said supply (Davis, 2021). Therefore loadshedding has been a significant contributing factor to a decline in expansion and capital investments (Davis, 2021). A reduction in PGM production, or in a worst-case scenario a stoppage in the local industry due to stage 6 loadshedding or above will hamper the world's ability to transition to sustainable forms of transport, and further reduce economic growth given the current and future importance of the industry to the South African economy (Odendaal, 2019). This is based on the assumption that platinum mining remains heavily dependent on Eskom's for electricity supply. However this is likely to change as several large platinum mining operations have indicated that they will be investing in onsite or near site renewable energy plants to reduce their demand from Eskom (Davis, 2021).

SMMEs are regarded as key drivers of economic growth in South Africa, accounting for the majority of businesses in South Africa, and employing 64% of the South African labour force as of Q1 of 2021 (SEDA, 2021). SMMEs are therefore key drivers of economic growth, job creation, and innovation in the economy (Bruwer et al., 2018). Infrastructure disruptions, such as loadshedding, reduces competitiveness of small business to a greater extent (than comparatively larger businesses) given their lower coping cost capacities (Mensah, 2018). In other words, SMMEs are particularly vulnerable to loadshedding, given that many cannot afford alternate sources of electricity or backup generators, and are forced to either limit or stop operations during loadshedding periods (Mbomvu et al., 2021). Given that South Africa already has a harsh economic environment for SMMEs, with 75% of SMMEs failing after operating for less than three years (Bruwer & Coetzee, 2016), persistent loadshedding further compounds the existing operations- and business environment challenges placed on these businesses, reducing their viability and decreasing their chances of long-term success and survival (Mbomvu et al., 2021). These impacts have been summarised in Table 1.

Beyond the direct impact on businesses, loadshedding continues to have a tangible impact on investor confidence, reducing investment from both international and local sources. International credit ratings agencies, which rate a debtor's ability to repay debts, have indicated that while current levels of loadshedding are unlikely to lead to a credit downgrading, if there is persistent and more sever loadshedding then this could contribute to a downgrading of South Africa's investment grade by credit rating agencies (Fin24, 2019a; Investec, 2022; Smit, 2021). South Africa had its credit rating downgraded in 2020 by both Fitch and Moody's, which while not triggered by loadshedding, have placed South Africa in an already difficult position (Cronje, 2020). The downgrading of a country's credit rating increases the cost of borrowing money on the international debt market – both for firms and the state – and reduces the amount of foreign direct investment flowing into a country (Elkhoury, 2008). As such, if the gap between Eskom's electricity supply and electricity demand continues, resulting in persisting or even worsening loadshedding, it is likely to contribute negatively to credit rating agencies outlook on the South African economy.

These impacts are also seen reflected in customer sentiment, where loadshedding tends to result in a reduction in capital investment and consumption expenditure from consumers, as well as reducing corporate investment as corporations see a decrease in local market growth due to reduced consumer expenditure (Chester, 2019). It has also been suggested that psychological panic after a power failure can be an indirect effect of blackouts (Shuai et al., 2018), this is likely the case in South Africa where the announcement of loadshedding is regularly met with disdain (Ebrahim, 2022), reducing citizens confidence in the South African government (Grootes, 2022; Ramalepe, 2022).

More importantly, if one considers the risk associated with intermittent power supply to medical facilities, the potential for loss of human life cannot be understated or quantified. While most medical equipment can manage the switch between grid fed power and back-up generators some crucial equipment such as those required for ventilation cannot (Mkize, 2019). Moreover, the cost associated with utilising back-up generators for medical facilities can be costly, with Netcare reported spending an average of R800 000 over a 6-month period on the diesel required to power their generators (de Wet, 2019). With approximately, 80% of South African citizens reliant on public health facilities, medical facilities will continue to be under significant strain during periods of loadshedding (Laher et al., 2019).

Finally, it is important to acknowledge the impact of poor governance, corruption, and a lack of maintaining infrastructure, and significant delays in the new build programme at Eskom which has ultimately resulted in increased borrowing. This coupled with the significant increase in electricity tariffs to generate revenue, despite stagnant demand has brought into question the viability of Eskom (Steyn et al., 2017). Eskom’s viability places a significant risk on the South African economy (Steyn et al., 2021). Eskom’s viability will continue to be questioned, given its debt burden, the loss in revenue from unsold electricity, and the reduction in demand from large scale consumers who may offset their reliance on Eskom through alternative energy source (Creamer, 2022b; Davis, 2021; Singh, 2022). Additionally, the Russian invasion of Ukraine has driven an increase in fuel prices, significantly increasing peaking power costs for Eskom in the short term due to their reliance on diesel as the main fuel source of their peaking plants (Creamer, 2022d).

Table 1 Economic impacts of loadshedding

	Economic impact			
User group	Direct	Indirect	Coping cost	Long-term/ macro-economic
Individuals	Psychological panic; citizen morale declined; negative customer sentiment	Cost of repairs as a results of power surges	Back-up power (usually diesel-powered generators) incl. capital expenditure and operating	Increased unemployment
	Reduced quality of life & and impedance of recreational activities	Cost of preventative measures to safeguard property during loadshedding	Cost of alternative sources of light i.e., candles, paraffin lamps etc.	Barriers to entry (for entrepreneurship)
	Increase cost of living	Cost of replacing food due to spoilage		Increased emigration
	Loss of working hours	Cost of postponed income		Less confidence of industry in the reliability of the power system
	Loss of employment	Risk to health and safety		Increased cost of living due to depreciating ZAR
Small Business (SMMEs)	Operational capacity underutilisation	Payment of operational costs while income and cash flows are halted	Back-up power (usually diesel- powered generators) incl. capital expenditure and operating expenditure	Increase in number of businesses shutting down due to reduced viability
	Increase in production cost	Cost for alternate sources of electricity		Increased insurance costs due to increased claims for damaged machinery
		Intermittent interruption to production operations		
		Intermittent interruptions resulting in temporary disruptions during loadshedding hours		Decreased sales due to reduced demand from customers:
		Persistent interruptions to operations due to machinery requiring extended running periods, and thus unable to run during consecutive loadshedding days		Consumers with reduced incomes
		Cost of repairs due to electricity surges		Commercial customers having reduced operations
		Loss of products due to spoiling from failing refrigeration		Loss of contracts due to reduced operational capacity
		Cost of preventative measures to safeguard products/premises during loadshedding		Reduction in employment or reduction in wage rates
		Reduction in firm productivity and competitiveness		
		Loss of market share		
Big business	Operational capacity underutilisation	Higher operating costs creating greater barriers to enter the market	Cost of protection technologies	Reduced investment into machinery and production, if loadshedding is perceived to be a persistent issue
	Increase in production cost	Costs for customers increases due to higher operational costs	Back-up power generators (fuel powered generators, increased battery storage capacity)	
		Reduced competition with international market		
		Greater bias towards more labour-intensive production methods		

		Value-chain disruptions		
		Loss of market share		
Investors		Reduction in potential ROI		Reduced investor confidence;
		Reduced investor confidence		Increase in cost of capital;
				Divestment
				Downgrading of credit rating if loadshedding is persistent and elevated
Economy wide/ Overarching	Interrupted economic activity resulting in a reduction in operational efficiency and sub-optimal utilisation of resources; reduction is sales	Reduction in firm productivity	Back-up power (usually fuel powered generators) capex and opex; opportunity cost of alternative investments	Reduction in international competitiveness (incl. trade competitiveness)
			Cost of protection technologies	Constrained expansion in industrial and services sectors
				Reduced demand for labour and employment
				Loss of skilled labour
				Reduced confidence in good governance & potential political friction

Source: Authors composition, including Goldberg (Goldberg, 2015)Mensah (2018), Shivakumar et at. (2017), Shuai et a. (2018)Rentschler et al. (2019), Blimpa & Cosgrove-Davies (2019), Investec (2022), The Financial Times (2022)

4.3. Response to loadshedding and the energy crisis

There have been a number of responses to the energy crisis, from protests, Eskom burning unimaginable amounts of diesel (5.7bn litres since 2012 see: Msomi (2022)), and embarking on a new build programme for some of the world's largest coal-fired power plants namely: Medupi and Kusile (4764MW and 4800MW respectively) (Eskom, 2016, 2021f, 2022e), to the department of energy DoE (now the department of mineral resources and energy (DMRE)) initiating an IPP procurement programme (DoE, n.d.), amendments to the Electricity Regulation Act now allowing private generators to develop up to 100MW of power without requiring a licence from NERSA (DRME, 2021), and more recently Eskom's unbundling as the monopoly- generator, transmitter and distributor of power in South Africa (Parliamentary Monitoring Group, 2021). A summary of some of the responses to loadshedding have been illustrated in Table 2, and expanded on in this chapter.

Eskom recognised and communicated the dire state of electricity supply in early 2007, including how they intend on addressing this. At the time Eskom implemented demand side management measures, increased expenditure on energy efficiency updates, and campaigns (Eskom, 2007). Eskom's demand side responses have included requesting South Africa's residents to reduce their electricity usage by turning off unnecessary lights and appliances, as well as the larger Demand Response Programme which has agreements with large-scale, industrial consumers to reduce their electricity consumption by a pre-agreed amount when national demand exceeds supply (Eskom, 2021g). Eskom's supply side responses include the building of Medupi, and Kusile power plants, which are some of the world's largest coal fired plants, and while marred in cost over runs and build delays are now somewhat operational (Illidge, 2022). While Kusile and Medupi are operational, they have both experienced maintenance issues which contributed to loadshedding in 2022 (Omarjee, 2022; Stoltz, 2022).

To address peak power supply issues Eskom has relied heavily on diesel-fired turbines, however this has been an incredibly costly exercise which has already cost Eskom R7.7bn in 2022 (Fin24, 2022), while costing Eskom approximately R54bn since 2012 (Msomi, 2022). From a maintenance perspective Eskom has recently announced the launch of a digital crowdsource platform to plug its skills gap (BusinessTech, 2022e), as well as seeking to rehire former employees to train and mentor current employees (Engineering News, 2022).

Eskom has sought annual price increases – which are often in excess of inflation as shown in Figure 3 – which in part are used to fund its maintenance program to reduce loadshedding (NERSA, 2021). Finally, on the 19th of September 2022 Eskom launched three programmes to secure emergency electricity generation in the light of severe loadshedding due to the lowest energy availability factor to date and worst year of loadshedding with 68 days of loadshedding as of September 26th 2022 (BusinessTech, 2022g). The programmes will focus on generators able to supply over one Megawatt, but will be made available to small producers over time (Eskom, 2022f). The Standard Offer Programme which will purchase power from companies with existing generation for three years at a fixed cost established each year; the Emergency Generator Programme which will purchase more expensive power when the grid is significantly constrained; and the Bilateral Power Import Programme which will see Eskom buying power from neighbouring countries (Eskom, 2022f).

In response to these issues the state has implemented several programmes to attempt to reduce the gap between Eskom's energy supply, and South Africa's demand, as well as addressing the structure of Eskom as the monopoly power supplier. These structural changes include the unbundling of Eskom, which took its first legal steps in 2021 with the unbundling of Eskom's transmission division into a separate company, and is expected to continue until 2023 with the unbundling of the distribution division from the generation division (Eskom, 2022b; ESI Africa, 2022). Further, the DMRE has announced plans to create a new state-owned enterprise – dubbed as Generation 2 – which will re-purpose three of Eskom's coal fired plants - planned for decommission - into gas fired plants, and will be manged by the DMRE rather than the Department of Public Enterprises (Prinsloo & Cele, 2022). Further, the DMRE has plans for the development of a second nuclear power plant (Prinsloo & Cele, 2022).

The South African government's main drive for new generation has been under the six BWs of the REI4P programmes, the RMI4P, and the CI4P. REI4P BW1 was introduced in 2011 (Pinto, 2021), and with BW 6 being the latest announced, and has recently had its capacity allocation doubled (IPPPP, 2022). A contributing factor to the current level of load shedding was the delay of BW 4 which was announced in 2014 and only signed in 2018 (Omarjee, 2018). However, given the pressing electricity crisis and important role REI4Ps have to play in the energy mix, BW6 was swiftly announced in 2022, only one year after the conclusion of BW5 (IPPPP, 2022), with BW7 set to begin in 2023 (Creamer, 2021b).

It was however recognised in 2020 that there remains a gap in the energy supply, given the pressing energy supply issues facing the country and the delay before BW5 plants would come online. As such RMI4P was announced in 2020, which sought to procure 2000MW of power to mitigate the risk of loadshedding and reduce the utilisation of diesel-fired peaking electrical generators (IPP Office, 2021b). It is important to note that the RMI4P differs from the REI4P in that it is technology agnostic, rather than specifying specific technologies (DMRE, 2021a). A further difference is that the power plants (dispatchers) will be providing electricity through a dispatch instruction only, whereas under REI4P electricity is provided whenever the plant is operational and providing electricity and are compensated on a take or pay obligation from the buyer (DMRE, 2021a). Electricity is, therefore, only provided by the RMI4P when it is called on by Eskom to reduce or avoid loadshedding, and to provide ancillary services to reduce the reliance on diesel-fired peaking generators (DMRE, 2021a). A further difference is that the tariffs do reflect dispatchability, voltage stability and storage cost.

Dispatchers have a minimum commitment of a 50% load factor in a year, with 95% of the price comprising of the electricity cost calculated at 100% load factor and at 75% load factor, the cost of grid connections, carbon taxes if applicable, operation and maintenance costs, variable costs, and fuel charge rates, with the remaining 5% accounting for the ancillary services (DMRE, 2021a). These two sets of requirements also provide the reasoning for the 20-year contract, because dispatchers provide electricity at the request of Eskom and are not providing constant electricity, they have a higher risk in operating as they are remunerated based on their provision of electricity (DMRE, 2021a). Hence, the DMRE has stated that the 20-year contract will allow for dispatchers to service the costs of operating and establishing, as well as debt, equity, and other obligations, and without which the price would have been triple its current amounts (DMRE, 2021a). Thus, the RMI4P successful bidders operate in a fundamentally different paradigm to those of the REI4P, and are more comparable to battery storage, hydroelectric pump storage, renewable plants paired with battery storage, or the diesel-fired generators currently being used to address peaking demand in South Africa.

In addition to these programmes an increase in coal-fired generation was sought under the coal independent power producers procurement programme (CI4P) which was announced in 2014, and commissioned two projects (namely Khanyisa and Thabametsi) which added an additional 863MW by 2019 and 2021 respectively (Department of Energy, 2016). However, both these projects failed to materialise as the consortium building Thabametsi lost their funding and eventually withdrew the project in 2020 (Toyana, 2020), while Khanyisa's EIA was set aside by the Pretoria High Court 2021 (Lerato, 2021).

Finally, in 2021 President Ramaphosa announced the private electricity generation plants up to 100MW would no longer be required to apply for a NERSA license to operate, allowing for large-scale embedded generation projects to be swiftly implemented (Cotterill, 2022).

These changes to South Africa's energy mix since loadshedding began has demonstrated a significant shift in the energy mix from mainly coal based generation to a transition towards a more balanced energy mix. These changes are evident when comparing the IRP 2010 to the IRP 2019, where there was a noticeable increase in the allocation of renewables – particularly wind energy – in the planned energy mix (DMRE, 2019b; DoE, 2010). IRP 2010 envisaged additional coal-fired capacity being added to the mix from 2027 to 2030, as well as a significant amount of gas generation (both open cycle and combined cycle), with the IRP 2019 reducing new coal fired plants planned down to one for 2027, and the gas allocation from 2019 onwards reduced from 7 646MW in IRP 2010 to 3000MW in IRP 2019 (DMRE, 2019b; DoE, 2010).

The focus on wind energy in the IRP 2019 is important to note, as it envisages 1600MW of wind energy added every year from 2022 to 2030, totalling 14 400MW, which is a significant increase when compared to the IRP 2010 which only plans for new wind builds after 2019, and those planned for before 2019 amounting to 3800MW (DMRE, 2019b; DoE, 2010). While explicit mention of new peaking plants are not outlined in IRP 2019, the DMRE acknowledges that extensive use of diesel fired OCGT plants will be needed in the short term which will be very costly, and that there is insufficient reserve capacity in the event of emergency plant breakdowns (DMRE, 2019b). The IRP 2019 estimates that in the short term there will be a 2000-3000MW supply shortage and it recommends that new power purchase programmes are undertaken (DMRE, 2019b). Within this context, it does appear that there is an opportunity for peaking generation as baseload is expanded to meet current demand. The demand for peaking generation may also continue once the gap in the baseload is met, as is typically the case when considering the needs of the system throughout the day. Modular gas generation, such as those offered by Karpowership for instance, can serve as baseload, mid-merit and peaking. However, the cost of these peaking plants should be balanced against the cost of expanded baseload generation to provide electricity in surplus of baseload to meet peaking demand, and the economic impact which failing to meet peak demand results in.

Moreover, it has already been acknowledged in the IRP2019 that gas to power technologies provide the flexibility required to complement renewable energy (National Department of Energy, 2019). Gas-fired power plants, when designed to operate flexibility, contribute to optimising energy systems in response to demand patterns given the variable supply of renewable energy. In other words, gas power does not serve to replace renewable energy in the energy mix, but rather supports the further penetration of renewable energy, provides long duration balancing resources, and ensures reliable supply when renewable energy generation is low. Again, this does not serve to combat battery storage (which is currently inadequate to support baseload requirements), as this provides short duration requirements of the network and will support with balancing variable renewables in real time (Townsend, 2019). Annexure A discusses the implication of an overreliance on OCGT as an economic risk, and compares OCGT generation to various energy generation technologies, across a number of parameters.

Table 2 Response to the energy crisis

	Short term response	Medium to Long Term response
Individual	Behavioural change; planning for loadshedding; switching to energy efficient appliances	Investment into small-scale generation (diesel generators, Solar PV, and battery storage) Emigration
Eskom	Power Alert (on SABC TV) Various campaign: 49M, Use electricity wisely/ Use electricity smartly campaign Increase generation capacity utilising new build peaking power stations (Ankerlig- and Gourikwa gas power stations completed in 2007)	Capacity expansion major projects (Camden, Grootvlei, Komati, OCGT etc.) New build programme (i.e., Medupi and Kusile coal fired power stations, Medupi commercially operational July 2021, Kusile 4/6 units commercially operational, completion estimated 2024/5) Sere Wind Farm (Commercial operation March 2015) Conversion of existing coal-fired power stations to alternative energy source (Invitation to tender for conversion of Komati power station to PV system in closing date: 07 July 2022)
Government (incl. DMRE and DPE)	Regional joint command centres convened	Initiation of IPP procurement programme (2013 Commercial operation of initial bidders under the REI4P) Unbundling of Eskom (announced in 2019) Electricity Regulation Act Amendment Bill for licence exemption up to 100MW for private power purchase agreements (October 2021)
REI4P		REI4P launched in March 2011 92 Renewable Energy IPP projects contracted (BW1-4) 6 323MW of electricity contracted
CI4P		Coal Baseload IPP programme launched in December 2014 Thabametsi failed to secure funding and withdrew (2020) Khanyisa EIA set aside by the Pretoria High Court (2021)
RMI4P		RMI4P launched in August 2020 8 preferred bidders announced March 2021, with 3 preferred bidders added in June 2021

Source: Authors compilation, including: Eskom (2007), Creamer (2011), DoE (2016), DMRE (2020), IPP Office (2021a), Eskom (2021e), Eskom (2021f), Eskom (2022d), Eskom (2022e), Allen & Overy (2022)

5. Conclusion

This report set out to present the global- and local energy context, demonstrate the economic impacts of loadshedding in South Africa, and how South Africa has responded to loadshedding in South Africa. There are a few key findings from this report.

While coal has been the main source of electricity generation both globally and in South Africa, there is an active and steady transition to alternative energy, including gas and renewables. This transition has been driven by the need to reduce greenhouse gas emissions to mitigate the climate crisis, and the improvement in cost efficiency of renewable energy relative to fossil fuel-based electricity generation. This transition has further been emphasised in the South African context, given the necessity of addressing the energy crisis and the persistent loadshedding.

Loadshedding has had a significant impact on the South African economy, reducing economic growth and recovery post Covid-19 restriction, and limiting firms' ability to operate and forcing businesses to bear the burden of coping costs, increasing the cost of living to individuals, and negatively impacting on investor sentiment. The impacts of loadshedding are either direct or indirect and have a long-term implication. For instance, loadshedding affects business directly through increasing production costs and reducing their ability operate optimally. Indirectly these businesses competitiveness is negatively impacted due to lower sales and increased operational cost, or the need to incur coping cost. In the long term, the cumulative impact of loadshedding results in decreased international competitiveness, reduced demand for labour, and stifling of expansion of key industrial sectors, among others. The impact of loadshedding has resulted in a reduction in economic growth (estimated at 3.1% in 2021) and decrease in employment (estimated at 400 000 in 2021 alone) with the impact being more significant for SMMEs relative to larger firms, although mining and manufacturing companies have been hard hit too.

For South African consumers loadshedding has resulted in interruptions to the service of medical support, interruptions to both the private and working lives, including interrupted work, increased time spent planning for and finding alternate solutions during loadshedding. Loadshedding has had a significantly negative impact on the South African economy which has resulted in the loss of jobs and a loss of potential jobs, and reduction in economic growth which has reduced the economy's ability to recover from the Covid-19 pandemic.

Finally, investor confidence in South Africa has been reduced, which has reduced the amount of both international and local investment into the South African economy, while loadshedding has had a negative impact on credit rating agencies outlook for South Africa.

Given this significant impact of loadshedding on the South African economy, Eskom and the government has embarked on several measures in an attempt to remedy the energy crisis. Eskom has attempted to meet the shortfall in electricity supply with diesel-fired open cycle gas turbines which has proven to be an expensive solution, costing Eskom approximately R54bn since 2021, launching a skills portal to source new skilled workers to train and mentor existing staff, establishing a maintenance plan to address plant breakdowns, and building Kusile and Medupi power stations. These measures, however, have failed to mitigate loadshedding as there have already been 100 days of loadshedding by September 2022 (Bloomberg, 2022b). The government has attempted to address the shortfall in electricity supply by procuring power from IPPs under the REI4P, CI4P and RMI4P programmes, the former of which has concluded four successful BWs and has seen significant cost declines for renewable generation technologies. BW- 5 and 6, and the RMI4P will continue to add to balancing the South Africa's energy mix, if these reach financial close. However, if Eskom's current maintenance issues persist, and the coal-fired plant decommissioning schedule is followed, it seems likely that loadshedding will continue until 2030.

Gas-based electricity production has an important role to play in the energy transition, as it provides a near term replacement for coal, with reduced GHG and particulate emissions, and able to provide similar baseload energy production, and has the advantage of being highly effective in providing load following and peaking power output. This provides an important synergy with renewable energy, reducing the fluctuations in electricity availability, as energy storage technologies advance to the point where they can smooth out the variability in energy provision which wind and solar experience.

In the interim however, Karpowership is able to provide dispatchable power within minutes of receiving a dispatch instruction and can do so at a cost less than Eskom's diesel-fired OCGT. Moreover, and should the need arise, Karpowership can provide stable baseload power while emitting almost half the GHG emissions of coal-fired power. More importantly, the Karpowership fleet can be deployed immediately with the 12-month timeframe to commercial operation being contingent on the construction of the infrastructure required (i.e., transmission lines, gas pipes, mooring etc.). Furthermore, given the temporary nature of Karpowership floating fleet, the vessels can easily vacate the port once the contract has been concluded.

It is within this context that the RMI4P bids by Karpowership should be considered, along with the other interventions already discussed. The economic impacts of loadshedding are significant and need to be addressed urgently to minimise its impact on the economy and mitigate the risk to energy security in South Africa. It is therefore reasonable to conclude that an expansion in electricity generation through IPP purchase agreements, for both baseload and intermittent supply, is necessary in the short-term to address the energy crisis, which will facilitate improved economic growth and development in South Africa.

6. Annexure A

Implications of an over-reliance on Open Cycle Gas Turbine (OCGT) energy generation

7. Introduction

The objective of the RMIP4 is to mitigate the short-term supply gap, ease the current electricity supply constraints and reduce the wide-scale usage of diesel-based peaking electrical open cycle gas turbines (OCGT) using alternative dispatchable energy technologies (DMRE, 2021a). During periods of peak electricity demand Eskom, South Africa's national power utility, relies on both the harnessing of water in motion i.e. hydroelectricity and hydro pumped storage, but also, the burning of liquid fuel through utilising open cycle gas turbines (OCGT) (Eskom, 2021c). Eskom's 14 peaking power stations account for approximately 5900MW of electricity and operate during peak periods – normally between 06:00 and 08:00, and 17:00 and 20:00 - or when the systems is constrained i.e., during periods where the demand is higher than the base-load can supply (Eskom, 2022a). Moreover, OCGT is classified as emergency reserves according to NERSA, with a limitation on the volume of generation and specified at a 1% load factor (NERSA, 2022).

Furthermore, gas-fired power plants, when designed to operate flexibly, contribute to optimising energy systems in response to demand patterns given the variable supply of renewable energy. In other words, gas power does not serve to replace renewable energy in the energy mix, but rather supports the further penetration of renewable energy, provides long duration balancing resources and ensures reliable supply when renewable energy generation is low (Townsend, 2019). The IRP 2019 supports the development of gas infrastructure in addition to new gas to power capacity proposed (National Department of Energy, 2019).

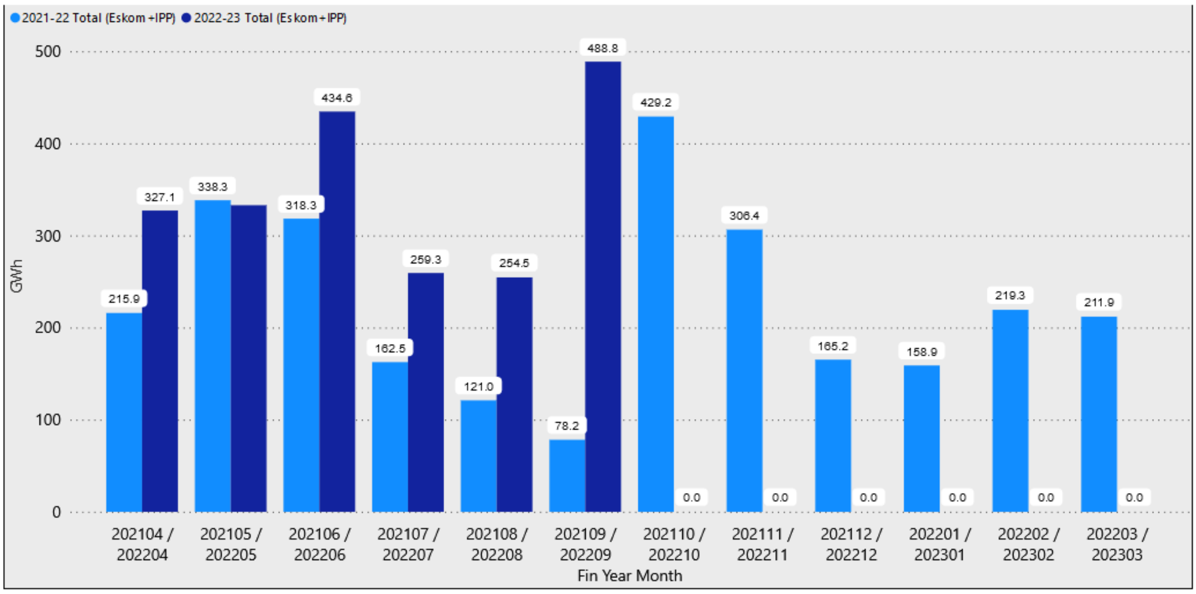
A further consideration is that the cost of generating power through utilising OCGT power stations is relatively high, as the cost of the primary energy source i.e., diesel in this case, has increased significantly (macrotrends, 2022b) while the ZAR has weakened relative to the US dollar (OECD, 2022). Eskom indicates that it costs approximately R500 000 per hour to operate their 150MW OCGT units or R10m per hour if all 20 OCGT units are operating simultaneously (702, 2021), and cost R4.1bn to operate during their financial year 2021 (Eskom, 2021d). Given the cost of operating OCGT, it begs the question, what are the implications of an over reliance on OCGT as an energy supply (or economic) risk mitigation measure during periods of peak demand?

This annexure serves to discuss in more detail the implication of an over-reliance of OCGT relative to alternative energy sources and builds on the discussion of Chapter 4.3. The two main points of the subsequent chapters are firstly to understand the implication of OCGT with respect to cost, reliability and environmental impacts, and secondly to compare OCGT to alternatives generation technologies.

8. The implications of utilising OCGT

Eskom has made use of OCGT to generate electricity during peak periods for a number of years now, and given the cost associated thereto the utilisation is tracked very closely (Eskom, 2020). It is evident that Eskom has utilised OCGT to a greater extent for the financial year to date, than the previous period, with September 2022 illustrating a stark contrast and demonstrating a reliance on OCGT that is clearly financially unsustainable (see Figure 7). This cost is then passed on to the customer, and Eskom in its most recent updated assumptions for its tariff application, for 2023, indicated that it intends to use R16.8bn of diesel in the next financial year – up from the R5bn initially applied for, which has, in part, driven the potential electricity increase to 38% (Businesstech, 2022; Moneyweb, 2022). This amounts to approximately five percent of the allowable revenue applied for in the financial year 2023/24 (Businesstech, 2022), but contributed to less than one percent of electricity supplied the previous financial year (Eskom, 2021d).

Figure 7 OCGT utilisation (Eskom)



Source: Eskom (2022h)

Eskom's reliance on diesel fired OCGT electricity generation while mitigating the risk of loadshedding by making up for the shortfall in baseload, poses a risk for the provision of stable electricity for several reasons, as without the primary energy peaking demand cannot be supplied. It is difficult to believe that OCGT is not being absorbed into the baseload supply requirement, and is being operated based on availability of diesel reserves (Smith, 2022), and not as intended i.e., for peaking or under system constraints. It is not surprising that these diesel reserves are now considered insufficient given the volume of diesel being burnt (Evans, 2022). Alternatively, if OCGT is considered an emergency reserve, then the extent of instances that are considered an *emergency* have certainly increased either in the frequency or in magnitude. The OCGT power stations are certainly not operating at a 1% load factor, but hovers around 16% annual load factor for the financial year 2022 to date[13] (Eskom, 2022g).

As noted above diesel-based electricity generation is significantly more expensive than other electricity sources. Based on Eskom's cost of burning diesel for a 150MW generator (702, 2021), this translates

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[13] As at 02 October 2022

to 333 c/kWh[14] which is just over double the cost of primary energy from Kusile and Medupi, and is 6.5 times the average cost onshore wind and 7.5 times the cost of solar PV projects approved under BW5 of the REI4P, and 150% the cost of the highest RMI4P bid.

Pram et al. (2022) through an analysis of Eskom's financial statements has, however, found that from 2018 to 2021 Eskom consistently over utilised OCGT and in 2021 did so by 591% more than initially planned. This results in significant costs for Eskom, already costing R7.7bn in 2022 as of September and has resulted in Eskom requesting R16.9bn - triple the amount previously requested by Eskom - for diesel due to an 60% increase for 2022 in expected demand for diesel OCGT due to its underperforming fleet, and at a load factor utilisation of 12% (Creamer, 2022e). The price increase also takes into account the rising cost of diesel due to the international energy crisis precipitated by the Russian Invasion of Ukraine (Creamer, 2022e).

In the context of climate change, an over reliance on diesel powered OCGT relative to alternatives such as renewable energy plus storage or LNG/ natural gas further increases SA's emissions. While diesel has a lower emissions factor than coal (74.10 kgCO2e/GJ relative to 94.6 kg CO2e/GJ for coal), it is far higher than LNG emissions (56 kgCO2e/GJ) (Lozynskyy et al., 2014), and significantly higher than renewable energy lifetime emissions which are the lowest of all energy sources. While renewable energy continues to be the cheapest and lowest emission source of peaking power (Dyson et al., 2021), and aligns with both South Africa's NDCs, and improves South Africa's prospects of attracting international funding, such as the $8.5bn Just Energy Transition Partnership negotiated at COP26 (Ngcuka, 2022) the current energy crisis also needs to be address urgently.

While OCGT power generation has been an important component of Eskom's fleet to deal with demand, Eskom's overreliance on OCGT to compensate for its aging coal fleet - which has resulted in considerable energy availability loss due to breakdowns (Evans, 2022) - has meant that the cost borne through electricity generation using OCGT has become a significant burden for the South African citizens, as Eskom tries to recover its cost through tariffs. It is evident that there is a case for increasing the baseload, and mid merit capacity. A comparison between OCGT and alternative energy generation technologies will be discussed in the subsequent chapter.

9. A comparison of generation technologies

This chapter provides a comparison of OCGT relative to a number of alternative energy generation technologies, and across a number of parameters. Although direct comparisons can be challenging, an attempt has been made to present a comparison across the following parameters for new build- and existing generation: levelized cost of electricity (LCOE), capital expenditure, decommissioning cost, commercial operation lead time, employment, and environmental impact among others. The

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[14] Calculation: (R500 000*100)/(150*1000), where Eskom states that it cost R500 000 an hour to operate 150 MW OCGT unites. Where there are 100 cents in a rand, and 1000KW in an MW.

comparison is tabulated in Table 3. When making comparisons between different power plants, it is important to understand the differing roles these play in the energy mix. Power plants are typically defined as baseload (providing consistent electricity given the average daily demand for electricity, this is the majority of power) (Energy Education, 2020), load-following (providing varying electricity supply which increases and decreases electricity production as demand fluctuates throughout the day) (Nuclear Power, 2022), and peaking power (providing electricity only when demand is at its maximum in a day, and over a short period of time) (Eskom, 2021c).

9.1. Cost elements

As highlighted in previous chapters, OCGT has a LCOE significantly higher than other utility scale generation technologies in South Africa. However, Pram et al (2022) demonstrates that as long as the price of LNG remains lower than R210/GJ then it remains cheaper to use LNG in OCGT than diesel in South Africa. For reference the price of LNG as of the 29th of September was approximately R126/GJ on the international market, but has reached prices as high as approximately R174/GJ in August of 2022 (Trading Economics, 2022) – although it is important to note that gas is a commodity and its highly likely that these (extraordinary) prices will come down once global stability is established (after the COVID-19 pandemic, and the Russia-Ukraine war). By contrast the local supply of natural gas, which is mostly fulfilled by Sasol, was recently raised to R133.34/GJ with a maximum of R273.43/GJ (Nyathi, 2022). It is important to note that while natural gas does present a cheaper alternative to diesel (Clark et al., 2022), significant investment into terrestrial gas fired plants and related infrastructure for piped gas will be required to transition from diesel to natural gas for OCGT and is highly likely to leave South Africa with stranded energy assets in the next 20 years (Halsey et al., 2022). This because the cost of renewable energy is already lower than all other energy sources, and set to continue to decrease, with similar trends seen in energy storage devices which have seen a significant cost decline in current technologies which are expected to continue in the future (Cole et al., 2021). Further cost reductions are expected in the future as new storage technologies are developed and current technologies are improved (Mongird et al., 2019).

Considering the LCOE, Karpowership is situated between solar PV and OCGT, making it an ideal candidate as a cost-effective consideration for South Africa's energy mix – given their differing production roles. LCOE studies in South Africa have already shown that battery storage is cheaper than OCGT, when utilising natural gas or diesel, for peaking, and both solar PV and wind are cheaper than natural gas CCGT for baseload requirements (Halsey et al., 2022). Thus, this *could* leave natural gas infrastructure stranded as lower cost renewable energy under cuts natural gas plants, either requiring these plants to shut down or to be subsidised to provide electricity at rate competitive with renewables (Halsey et al., 2022). This has already been seen in countries such as India and the United States of America, which have lost billions of USD due to new gas builds being unable to recuperate the costs of initial capital investments (Halsey et al., 2022). New gas plants built in isolation are more likely to become stranded, however if built in conjunction with renewable energy, and thus providing grid stabilisation, gas plants are less likely to become stranded. The reasoning for this is that renewable energy plants provide intermittent energy supply and needs large scale battery storage to provide the requisite stability in energy supply. This poses an issue as large scale battery storage will need to increase storage capacity by 44 times by 2030 to meet global demand, which will require substantial increases in battery manufacturing (IEA, 2022), and the constrained supply of batteries is likely to be taken mostly by developed countries, which are able to outbid developed countries for key global resources. Thus, gas plants - which are less emissions intensive than coal plants – when used to complement and stabilise renewable energy's intermittent energy supply, can enable a greater deployment of renewable energy, thus reducing the likelihood of stranding before 2050 (Mohammad et al., 2021; Promethium Carbon, 2022; United Nations Economic Commission for Europe, 2020). The issue of stranded assets is further reduced when considering the Powerships, as the significant costs incurred from developing terrestrial gas power plants are not required, including expensive gas pipelines or utilising trucks to transport gas. Due to the fact that the Powerships are pre-build, the capital costs are distributed amongst Karpowership's international costs, rather than being tied to a single project, and thus the risk of stranding due to unrecovered costs is significantly reduced. This risk is further reduced as the Powerships are able to leave the project sites when the contract is concluded, eliminating the risk of mothballing, or requiring subsidisation from government to be cost competitive with renewable energy.

In terms of capital expenditure (Capex), Karpowership is the least cost option for new plant builds, followed up OCGT, however this does not consider the cost of building the relevant gas piping infrastructure or transportation costs required if piped natural gas is not utilised. While the cost difference is in the favour of OCGT, the marginal savings is likely to be outweighed by the long-term cost increases of the primary energy. It is important to note that floating power ships in recent years have provided an alternative to land-based gas-to-power plants with the advantage of having lower Capex due to the standardised nature of the Powership, built in shipyards dedicated to their construction (Wyllie, 2021). When compared to solar PV, Karpowership is still cheaper albeit marginally however is significantly so relative to onshore wind. It is however important to note that renewable energy and OCGT fulfil different electricity production roles unless the renewables are coupled with battery storage.

Finally, it is important to consider the decommission costs of power plants, which involves the full dismantling of power plants, salvaging and sales of usable materials, disposal of waste products, and remediation of the land (Raimi, 2017). Table 3 indicates that decommissioning costs are highest for nuclear, reflecting the estimates for the decommissioning costs of Koeberg power station of approximately R42bn (Kings, 2016; Winkler, 2018). The next highest cost is for coal-fired plants, and this value is driven by the substantial environmental costs of decommissioning coal-fired plants such as disposal of coal ash, and asbestos and other harmful materials used in the construction of older plants (Raimi, 2017). Gas fired plants by contrast are significantly less costly to decommission because there are far lower fuel waste disposal costs, although there is considerable time spent cleaning and removing fuel storage tanks – as well as having significant scrap steel value which reduces overall costs (Raimi, 2017). Karpowership, however, has the lowest decommissioning cost. Comparison costs for renewables are more difficult because there have been far fewer solar PV and wind plants decommissioned and as such costs are projections, however these plants are on average approximately half the cost of decommissioning coal plants, but significantly more expensive than decommissioning of gas fired plants. These costs are expected to decrease overtime, as more experience with decommissioning these plants is gained.

9.2. Human and environmental considerations

It is critical to consider both the emissions factor, impact on human health, and land use of the various energy generation technologies to provide a holistic understanding of the effects of the various energy generation technologies and not purely on a cost basis. For these metrics, the United Nations Economic Commission for Europe's (UNECE) Carbon Neutrality in the UNECE Region: Integrated Life-Cycle Assessment of Electricity Sources report was utilised. The UNECE takes a cradle to grave approach to all three metrics, considering not only the impact of emissions and land use of the power plants themselves, but the manufacturing, deliver, and eventual disposal of the materials required in the power plants construction (2021).

From Table 3 it is evident that nuclear energy has the lowest emissions factor, followed by hydroelectric, onshore wind, solar PV, new build coal-fired plants (assuming carbon capture and storage [CCS] is installed, without this it is the worst emitter), and then natural gas plants (assumed without CCS, with CCS natural gas has lower emissions than coal fired plants) and Karpowership. However, this comparison does not describe the emissions factor of diesel fired OCGT, for this we refer to Lozynskyy et al (2014). Emissions Intensity Benchmarks for the South African Carbon Tax, which demonstrates that coal emissions have 127% higher CO_2 equivalent emissions (94.6 CO_{2e}/GJ) than diesel (74.10 CO_{2e}/GJ), while natural gas produces 75.5% of the emissions (56.10 CO_{2e}/GJ) that diesel does. This demonstrates that natural gas provides a reduced emissions factor when compared to diesel, however it is still far higher solar PV and onshore wind.

In terms of human toxicity, coal continues to have the highest impact, which is primarily driven by arsenic emitted to surface and groundwater during the coal extraction phase, and the treatment of coal ash in landfills (United Nations Economic Commission for Europe, 2021). These values are even higher for South Africa, given that South African coal has higher levels of arsenic (United Nations Economic Commission for Europe, 2021). This is followed by natural gas (mostly to the materials used in gas-to-power plants), and then by solar PV, the latter of which is higher than other renewables due to its high use of copper as an input material, where arsenic is released during copper mining (United Nations Economic Commission for Europe, 2021). No toxicity information is available for Karpowership.

Finally, considering land-use we again see that the highest values are still from coal-fired generation. UNECE (2021) scores power plants based on its direct and indirect impact on land-use, considering both the area occupied by the plant, and materials and fuel needed to supply the plant and assigning points accordingly. This metric, therefore, considers not only the area of land used, but what type of land is being impacted (urban or agricultural), and reflects the overall land quality considering aspects of erosion resistance, mechanical filtration, physicochemical filtration, groundwater regeneration, and biotic production. Coal mining for instance will have a higher score with high land occupation during the extraction phase (open pit or underground), and the use of timber braces in mines which impacts forestry. From this perspective we see that natural gas plants generally having a lower land-use impact that other fossil fuels, which is due to the nature in which natural gas is extracted from underground. Solar PV on the other hand has a significantly high score (6 times that of gas peaking for instance) for two reasons, firstly there are large amounts of copper utilised in solar PV panels, which leads to a high mining impact during material sourcing. Secondly, solar PV plants are typically built over a larger geographic area than most power plants as multiple panels are required. Given the nature of the Powership, the land-based impact is minimal as the land utilised is usually land that is already transformed (like a port, including its bulk infrastructure), with a small footprint required for the transmission lines, and to store replacement parts for instance.

In terms of employment, it is important to understand the bearing of employment opportunities to the Just Transition, and how new build plants will contribute to improving the communities in their vicinity. Traditionally in South Africa the coal industry has been a major employer, with jobs mainly originating in coal mining, however when considering employment in coal-fired plants alone the amount of employment drops. Table 3 demonstrates that new build coal-fired plants create 0.11 job-years/GWh on average, which is the lowest of all generation technologies presented in this comparison. NICE (2021) does not provide values for OCGT and CCGT gas plants individually, but does provide an overall value of 0.10 for natural gas which is similar to that of coal-fired power stations. Given the nature of the Powership, it has the lowest employment factor, however with respect to the Karpowership project, it will create developmental opportunities through implementation of its economic development plan (see Karpowership SA (2022a) (2022b) (2022c)).

The largest number of jobs are created in solar PV and is a key argument behind the growth creating potential of a transition to renewable energy. Onshore wind, and utility scale solar PV technologies create the largest portion of jobs during the construction and instillation period, with the next largest amount concentrated in maintenance and operation (although maintenance and operations employment is expected to exceed construction past 2030), with a lower amount in manufacturing (Ram et al., 2020). Expectations for Sub-Saharan Africa is that employment is likely to be comparatively higher than other regions due to the use of more labour-intensive techniques. Globally it is expected that solar PV will replace coal as the major energy sector employer by 2050, with around 22.2 million jobs by 2050 (Ram et al., 2020).

9.3. Operational performance

Power plants typically fulfil one of three roles namely, baseload power, mid-merit/ load-following, and peaking power, although these roles are becoming increasingly blurred as new technologies are developed. Baseload power plants provide constant electricity at their maximum output and consist of the following power plant types: Coal, nuclear, CCGT or Combined Cycle Reciprocating gas engines, and hydro power – although the latter two can also be load following and peaking power respectively.

Solar PV and wind resources also fall under baseload, but are intermittent energy sources due to their dependence on weather conditions at any given time. Secondly, load-following plants are ones which provide varying electricity output dependent on fluctuating electricity demand, these generation technologies include: OCGT, floating Powerships that utilise combined cycle reciprocating gas engines, and CCGT.

OCGT is included here due to Eskom's overreliance on OCGT for load following, and thus use outside both NERSA and international definitions of peaking power (Eskom, 2022g; NERSA, 2022). Finally, peaking power is defined as power plants which are activated for the shortest amount of time and provide electricity demand exceeds both baseload and load-following supply. Historically this role has been filled by OCGT and hydropower due to their fast speed up times, however battery storage, and in future hydrogen fuel cells, are also providing new means of quickly responding to grid demand.

Considering the application of OCGT as peaking power and understanding the speed at which this technology can respond is important. *Speed of Response to Load Changes* tabulated in Table 3 which indicates the percentage of power capacity able to come online in one minute, therefore a higher value is better as it indicates a larger percentage of power capacity can come online. It is evident that natural gas does provide some of the fastest speeds for providing the most electricity in the shortest amount of time. Diesel OCGT provides the fastest response time, and as such are well designed for their role as peaking power. The Floating Powerships are noted as having a very fast speed of response, with between 12.5% capacity per minute from a cold start to 25% of contracted generation capacity, and 20% per minute from that point to 100% contracted generation capacity. This fast speed of response illustrates the ability of the Floating Powerships to respond to dispatch demands, while utilising systems which are more fuel efficient than OCGT. This is a key advantage of the Karpowership in the context of loadshedding, where dispatchable power is required to respond quickly to fluctuations in demand. It is important to note that battery storage has the most rapid response rate as it can instantaneously discharge into the grid, albeit constrained by storage capacity if the function is needed for an extended period of time.

Capacity or load factor is considered alongside the speed of response, which is a representation of the utilisation rate of a power plant measured as average load divided by total load over a given time period. Karpowership has the highest capacity factor at 96%, and furthermore if planned or unplanned maintenance is required only one generator is offline, with more than 20 available to generate at any given time. Other generation technologies such as nuclear and new build coal-fired (specifically Medupi) have capacities of 85-92% and 85% respectively. This is expected for baseload plants. Hydroelectric IPPs by comparison have a lower capacity factor of 69%, while onshore wind has a capacity factor of 39%, and solar PV has 24%. These values reflect their varying use cases, and generation abilities, with wind and solar PV being more sporadic in power provision due to their dependence on weather conditions. By contrast OCGT sits at between 6 and 12%, which is in fact far higher than the capacity factor designated to them as peaking plants by NERSA, however it does reflect the plants' ability to increase electricity generation on demand.

From the perspective of commercial operational lead time, it is again evident that coal-fired plants take the longest time to build, with Eskom estimating the build time for new plants at 96-120 months, and nuclear taking the same amount of time (Eskom, 2022a), although internationally there is a shorter lead time of 86 months for nuclear (Statista, 2022a). OCGT has a significantly faster build time at 12-36 months (Eskom, 2022a), and this is likely due to the fact that the gas turbines are pre-build, and the overall plant has a smaller build size. This is comparatively faster than CCGT, which have a longer lead time, at typically around 36 months (Gross & Lyons, 2015). As with previous comparisons in the section, renewable energy has the fastest build time, with the IPP Office (2021a) placing build time of wind and solar PV plants at between 15-18 months. However, Karpowership and FSRUs are immediately ready for deployment, and the 12-month lead time is associated with the construction of infrastructure (i.e., transmission lines, gas pipes, mooring etc.). The lead times for floating Powerships do differ from the land based natural gas plants, as they typically have lower commercial operation lead times as ships in many cases are pre-built and then sailed into the requisite port (Wyllie, 2021). Also, considering that the Powerships are already constructed there is no risk associated with securing finance to commence with the project. From this perspective the fastest means of bringing new electricity generation onto the grid is through Karpowership.

Turning to the typical design life, or useful life of power plants, the longest time for hydropower plants which typically have a lifetime of 60 years. New build coal-fired plants (Kusile and Medupi specifically) follows with an estimated lifetime of 50 years, while nuclear (specifically Koeberg) had an initial lifetime of 40 years, but which is currently being extended by 20 years through on-going refurbishments (Diemen, 2022). By comparison gas peaking plants and CCGT have a life span of 30 and 34 years respectively, while solar PV has a lifespan of 25-40 years, and onshore wind has a lifetime of 20-25 years. Karpowership has a similar life to onshore wind, with the advantage being that if it reaches its end of life the vessel can simply be replaced with a new sister vessel from the fleet. These figures are important to consider in the context of their Capex and LCOE, as longer lifespans allow for costs to be recovered over a longer period. This, however, does pose a challenge for new gas-based generation builds (except for Karpowership), which will need to be phased out by 2050 if South Africa is to achieve Net Zero as stated in the Presidential Climate Commission’s Just Transition Framework (2022).

Table 3 Conventional generation vs alternative energy generation technologies

Parameters	New build coal-fired	Existing coal-fired	Nuclear	Onshore Wind	Solar PV (Utility scale)	Gas peaking	Karpowership[15]	Gas - Combined cycle gas turbine (CCGT)	Hydro
LCOE (c/kWh)	96 – 225* (Lazard, 2021a)	55 – 70* (Lazard, 2021a)	194 – 302* (Lazard, 2021a)	68 – 105** (Lazard, 2021a)	65 – 203** (Lazard, 2021a)	296 – 355** (Lazard, 2021a)	More than Solar PV, but less than low-end gas peaking	105 – 149** (Lazard, 2021a)	78* (International Renewable Energy Agency, 2019)
Capex (ZAR/kW)	43 634 – 92 075* (Lazard, 2021a)	N/A	115 371 – 189 327* (Lazard, 2021a)	15 160 – 19 968* (Lazard, 2021a)	11 832 – 14 051* (Lazard, 2021a)	10 353 – 13 681* (Lazard, 2021a)	Lower than Gas peaking and CCGT	10 353 - 19 228 (Lazard, 2021a)	Significant variability (Context specific)
Decommissioning cost (c/kWh)	212.99 **** (Raimi, 2017)	212.99 **** (Raimi, 2017)	R42bn ***** (Kings, 2016; Winkler, 2018)	92.84 **** (Raimi, 2017)	103.76 **** (Raimi, 2017)	27.31 **** (Raimi, 2017)	0.5% - 1.3% of Capex	27.31 **** (Raimi, 2017)	
Commercial operational lead time (Financial Close to operation)	96 -120 months (Eskom, 2022a)	N/A	96 -120 months (Eskom, 2022a) 84 months (Statista, 2022a)	12 – 18 months (Heneghan, 2019) 15 – 28 months*** (IPP Office, 2021a)	12 – 18 months (IFC, 2022) 15 – 28 months*** (IPP Office, 2021a)	12 – 36 months (Eskom, 2022a)	12 months	36 Months (Gross & Lyons, 2015)	
Typical Design life or Useful life	50 years (Kusile and Medupi) (Blignaut, 2012)	N/A	40 years (Koeberg - without refurbishment) (Fin24, 2019b)	20 – 25 years (Kis et al., 2018; NREL, 2016)	25 – 40 years (NREL, 2016)	30 years (Fathi et al., 2016)	20 years (contract period in South Africa) Similar to onshore wind	34 years (Kis et al., 2018)	60 years (Kis et al., 2018)
Capacity Factor (% of available power)	85% (Medupi) (SA Government News Agency, 2022)	76.8% (Kriel) – 93.8% (Matla) (Eskom, 2021b)	85-92% (Yellend, 2016)	39% (IPP Office, 2021a)	24% (IPP Office, 2021a)	6-12% (Eskom's OCGT usage) (Creamer, 2022e)	96.4%	Significant variability (Context specific)	69% (IPP Office, 2021a)
Speed of response to load changes (% capacity/minute)	4-6 **** (Ramirez-Meyers et al., 2021)	4-6 **** (Ramirez-Meyers et al., 2021)	0.26-2 **** (Ramirez-Meyers et al., 2021)	Weather dependent (Ramirez-Meyers et al., 2021)	Weather dependent (Ramirez-Meyers et al., 2021)	NGCC: 0.66-8 **** NG Boiler: 7 **** NGCT: 25 **** (Ramirez-Meyers et al., 2021)	12-20	0.66-8 **** (Ramirez-Meyers et al., 2021)	15-25 **** (Ramirez-Meyers et al., 2021)
Application	Baseload (Lazard, 2021a)	Baseload (Lazard, 2021a)	Baseload (Lazard, 2021a)	Intermittent (Lazard, 2021a)	Intermittent; Peaking (Lazard, 2021a)	Peaking; Load-following (Lazard, 2021a)	Baseload; Peaking; Load-following	Load-following; Baseload (Lazard, 2021a)	Baseload, Peaking (Clarke, 2012; Eskom, 2021c)
Employment (job-years/ GWh)	0.11**** (NICE, 2021)	N/A	0.14**** (NICE, 2021)	0.16**** (NICE, 2021)	0.87**** (NICE, 2021)	Significant variability (Context specific)	0.02	Significant variability (Context specific)	0.27 – 0.9 (Wei et al., 2010)
Emissions (gCO2/kWh)[16]	341*[17] (United Nations Economic Commission for Europe, 2021)	1003.5* (United Nations Economic Commission for Europe, 2021)	5.5* (United Nations Economic Commission for Europe, 2021)	11.9* (United Nations Economic Commission for Europe, 2021)	52.5* (United Nations Economic Commission for Europe, 2021)	458* (United Nations Economic Commission for Europe, 2021)	508.5	458* (United Nations Economic Commission for Europe, 2021)	8.55* (United Nations Economic Commission for Europe, 2021)
Land use (Points/kWh)[18]	3.1* (United Nations Economic	2.15* (United Nations Economic	0.06* (United Nations Economic	0.105* (United Nations Economic	2.85* (United Nations Economic	0.45* (United Nations Economic	Not available	0.45* (United Nations Economic Commission for Europe, 2021)	0.165* (United Nations Economic

[15] Due to the proprietary nature of the Karpowership technology, only some information was made available for the purposes of the report. This information was sourced directly from Karpowership and is based on the generation technology that will be deployed for the South African projects.

[16] Emissions are considered over the lifetime of the project, and as such also considers emissions from production, and transport of construction materials, and emissions from the decommissioning process.

[17] Assuming carbon capture systems are installed.

[18] United Nations Economic Commission for Europe (UNECE) scores power plants based on its direct and indirect impact on land use, considering both the area occupied by the plant, and materials and fuel needed to supply the plant and assigning points accordingly. Thus, this considers not only the area of land used, but what type of land is being impacted (urban or agricultural), and as such reflects the overall land quality considering aspects of erosion resistance, mechanical filtration, physicochemical filtration, groundwater regeneration, and biotic production e.g., coal mining will have a higher score with high land occupation during the extraction phase (open pit or underground), and the use of timber braces in mines which impacts forestry.

	Commission for Europe, 2021)	Commission for Europe, 2021)	Commission for Europe, 2021)	Commission for Europe, 2021)	Commission for Europe, 2021)	Commission for Europe, 2021)			Commission for Europe, 2021)
Human Toxicity (non-carcinogenic) (CTUh/TWh)[19]	123,5* (United Nations Economic Commission for Europe, 2021)	82,5* (United Nations Economic Commission for Europe, 2021)	5,3* (United Nations Economic Commission for Europe, 2021)	2,9* (United Nations Economic Commission for Europe, 2021)	11,45* (United Nations Economic Commission for Europe, 2021)	12,35* (United Nations Economic Commission for Europe, 2021)	Assumed to be similar to other gas-based generation technologies	12,35* (United Nations Economic Commission for Europe, 2021)	1,1* (United Nations Economic Commission for Europe, 2021)

* Global
** South Africa
*** Wind and Solar combined
**** United States of America
***** Not measured in c/kWh but ZAR, and reflecting total cost

[19] The UNECE considers the impact on human toxicity from power generation projects ranging from emissions during the extraction of construction materials to the emissions of waste after construction.

10. Conclusion

As expected, an over-reliance on OCGT poses an economic- and energy security risk to the South African economy. This is because of two factors, firstly, the cost, and secondly because of the divergence from its intended application as a peaker[20].

OCGT is comparatively more expensive than the alternatives including, Karpowership, coal-fired power, onshore wind, utility scale PV, nuclear and CCGT, but more importantly its evidently more than the South African consumer can afford – simply looking at the difference between inflation and the tariff increases over the last two decades is evidence thereof. OCGT is also vulnerable to volatility associated with the supply and demand of the primary energy source (in this case diesel), and the volatility of the local currency (ZAR) relative to the USD – which has been depreciating over the same period.

Perhaps more concerning, is the application of the OCGT peaker being utilised to supplement baseload electricity supply constraints far above the 1% (load factor) emergency reserve requirement. This is evident from both the (over) utilisation of the OCGT (illustrated in Figure 7) and the load factor for the financial year to date hovering around 16%. What is further evident is the speed of response of Karpowership with power being dispatchable within minutes of receiving the dispatch instruction.

Apart from this, OCGT is more harmful in terms of emissions and human toxicity, than onshore wind, solar PV, and gas power (whether terrestrial or Powership), but less harmful in terms of its land-use relative to solar PV, although it has more land-use than Powerships. Solar PV, onshore wind and OCGT have similar lead times to commercial operation, which are longer than that of Powerships, and once operational OCGT is far more responsive to demand than onshore wind and solar PV, although it is only marginally more rapid than Powerships with a few minutes' discrepancy.

Considering the comparison presented above, a balanced energy mix is required to ensure that energy security is maintained, economic productivity is facilitated, and environmental impacts are minimised. An imbalance in the energy mix will inevitably compromise one or more of these three factors. At the moment, an over reliance on OCGT is a symptom of an imbalance in the energy mix and a deficit of baseload, and comes at a significant cost to the consumer. More importantly, this imbalance needs to be remedied urgently, with a remedy in line with the IRP 2019 and is likely one which requires both gas and renewables. Within this context the Powerships provide a strong alternative to OCGT due to the rapid dispatch speeds, ability to provide baseload and load following power, produce less emissions, and support the deployment of greater renewable energy resources by providing flexible electricity production.

[20] This stems from, and as indicated in the main body of this report, an aging coal fleet, lack of maintaining infrastructure, and mismanagement of resources among others.

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environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

	(For official use only)
File Reference Number:	
NEAS Reference Number:	DEA/EIA/14/12/16/3/3/2007
Date Received:	02 November 2020

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

The Proposed Gas to Power Powership Project at the Port of Richards Bay, Umhlathuze Local Municipality, King Cetshwayo District, Kwazulu-Natal.

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447
Pretoria
0001

Physical address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Environment House
473 Steve Biko Road
Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

1. SPECIALIST INFORMATION

Specialist Company Name:	Afro Development Planning Pty Ltd				
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	1	Percentage Procurement recognition	135%	
Specialist name:	Marco Steenkamp				
Specialist Qualifications:	MCom Transport Economics, PGDip Development Finance, BCom (Hons) Transport Economics, BCom Economics				
Professional affiliation/registration:	Member of the CILTSA				
Physical address:	3 Falls Nature Estate, eThekwini, 3652				
Postal address:	3 Falls Nature Estate, eThekwini, 3652				
Postal code:	3652		Cell:	084 486 0867	
Telephone:			Fax:		
E-mail:	marco@afrodevplan.co.za				

2. DECLARATION BY THE SPECIALIST

I, _____Marco Steenkamp_____________, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

Afro Development Planning Pty Ltd

Name of Company:

October 2022

Date

3. **UNDERTAKING UNDER OATH/ AFFIRMATION**

I, __Marco Steenkamp___, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signature of the Specialist

Afro Development Planning Pty Ltd

Name of Company

31 October 2022

Date

Signature of the Commissioner of Oaths

2022/10/31

Date

J R Nel

COMMISSIONER OF OATHS EX OFFICIO
CHIEF LEGAL ADVISOR
SOUTH AFRICAN POST OFFICE LIMITED
4 NQUTU ROAD HILLCREST 3610

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

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3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447
Pretoria
0001

Physical address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Environment House
473 Steve Biko Road
Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

TS. P2

1. SPECIALIST INFORMATION

Specialist Company Name:	**Afro Development Planning Pty Ltd**			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	1	Percentage Procurement recognition	135%
Specialist name:	**Tasneem Steenkamp**			
Specialist Qualifications:	**MPhil Sustainable Development Planning & Management, PGD Sustainable Development, BSc. (hons) Environmental & Geographical Science, BSc Environmental Science**			
Professional affiliation/registration:	**SACNASP Environmental Scientist 400131/15** **Candidate EAP (awaiting confirmation)**			
Physical address:	**3 Falls Nature Estate, 19 Debengeni Road, Waterfall, Durban, KZN**			
Postal address:	**Same as physical**			
Postal code:	**3652**	Cell:	**060 521 7919**	
Telephone:		Fax:		
E-mail:	**tasneem@afrodevplan.co.za**			

2. DECLARATION BY THE SPECIALIST

I, ***Tasneem Steenkamp***, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

Afro Development Planning

Name of Company:

25/10/2022

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, ***Tasneem Steenkamp***, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signature of the Specialist

Afro Development Planning

Name of Company

25/10/2022

Date

Signature of the Commissioner of Oaths

2022/10/25

Date

Phumzile Shabalala

COMMISSIONER OF OATHS EX OFFICIO
CHIEF LEGAL ADVISOR
SOUTH AFRICAN POST OFFICE LIMITED
4 NQUTU ROAD HILLCREST 3610