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How Has the Current Electricity Crisis in South Africa Affected the Development of Renewable Energy within the Independent Power Producer Procurement Programmes?

Sub-Question: Which factors are impacting progress in the development of renewable energy in South Africa?

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This thesis examines the effects of South Africa's electricity crisis on the government-driven development of renewable energy from 2007 to 2023 by testing the applicability of the energy security framework. The electricity crisis presents itself through regular electricity cuts, extreme power tariff rises and a lack of long-term sustainability due to the high reliance on coal and Eskom, the monopolistic electricity utility. Consequently, South Africa's economic development and social well-being are greatly affected.
Incorporating quantitative and qualitative evidence from government and Eskom documents, independent reports as well as newspaper articles, this thesis demonstrates that South Africa's energy insecurity drives the use of renewables as a supplementary energy source in the national grid. It argues that green energies' decreasing prices, natural abundance and diverging risk structure compared to fossil sources as well as the IPP programmes' lauded design have supported this. In contrast, exhausted national grid capacities, Eskom's monopoly and influence in the renewable procurement as well as corruption scandals have created severe delays in the progress of renewables in South Africa, thus presenting major barriers to change.

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Table of Contents

1. Introduction ... 1
1.1. Scope ... 2
1.2. Outline of the Thesis ... 3
2. Background ... 4
2.1. South Africa's Electricity Sector ... 4
2.2. The Electricity Crisis ... 5
2.3. Mitigation of the Electricity Crisis ... 8
3. Literature Review and Theoretical Framework ... 11
3.1. Energy Security Framework ... 11
3.1.1. The Role of Energy Security for Renewable Energy ... 12
3.1.2. Empirical Findings: Energy security as a driver for renewables ... 13
3.2. Energy Security in South Africa's Electricity Crisis ... 14
3.3. Mitigating South Africa's Electricity Crisis with Renewables ... 15
4. Data and Method ... 18
4.1. Research Design ... 18
4.2. Data Collection ... 18
4.2.1. Quantitative Data ... 18
4.2.2. Qualitative Data ... 19
4.3. Methods for Analysis ... 20
4.4. Limitations of Research Design and Data Collection ... 20
5. Analysis and Findings ... 22
5.1. Development of Renewables since the Electricity Crisis ... 22
5.1.1. Overview REIPPPP ... 23
5.1.2. Overview RMIPPPP ... 24
5.2. Impact of Energy Security on Renewable Energy in South Africa ... 24
5.3. Factors Affecting Renewables' Progress ... 27
5.3.1. Supporting Factors for Renewables in South Africa ... 28
5.3.2. Hindrances for Renewables in South Africa ... 28
6. Discussion of Results ... 30
6.1. South African Electricity Crisis as Driver for Renewables ... 30
6.2. Barriers for Renewables' Development in South Africa ... 33
7. Conclusion ... 36
References ... 38
Appendix A: REIPPPP and RMIPPPP Databases ... 53
Appendix B: Descriptive SPSS Statistics of REIPPPP Database ... 56
Appendix C: Summary Table Qualitative Analysis ... 57

List of Abbreviations

BW	Bid Window
CSIR	Council of Scientific and Industrial Research
CSP	Concentrating Solar Power
DMRE	Department of Mineral Resources and Energy
GW	Gigawatt
GWh	Gigawatt hour
IEA	International Energy Agency
IPP	Independent Power Producer
kWh	Kilowatt hour
MEC	Minerals-Energy Complex
MW	Megawatt
OCGT	Open Cycle Gas Turbine Station
PPA	Power Purchase Agreement
PV	Photovoltaic
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RMIPPPP	Risk Mitigation Independent Power Producer Procurement Programme

List of Tables

Table 1: Energy Security Dimensions within South Africa's Electricity Crisis 15
Table 2: Overview of Pertinent REIPPPP and RMIPPPP Statistics 24
Table 3: Overview of Qualitative Analysis Results for RQ1 (Source: Appendix C) 25
Table 4: Overview of Qualitative Analysis Results for RQ2 (Source: Appendix C) 28
Table 5: Energy Security Dimensions within South Africa's Electricity Crisis 30

List of Figures

Figure 1: Eskom's Plant Mix for Electricity Generation in South Africa, as of June 2022 4
Figure 2: Yearly Loadshedding in South Africa per Stage and in Total in GWh 6
Figure 3: Distributed Electricity in South Africa's Grid from 2000 to 2022 6
Figure 4: Inflation-adjusted Average Prices for Eskom-transmitted Electricity in South Africa from 2003 to 2021 7
Figure 5: South Africa's Electricity Production by all Power Producers by Source for 2020 ... 9
Figure 6: Share of Renewable Electricity in South Africa's Electricity Mix, 2000-2021 22
Figure 7: Operational Capacity of Wind, Solar PV and CSP in South Africa, 2013-2022 23
Figure 8: Generation in Eskom's Electricity Grid from April 2018 to April 2023 26
Figure 9: Electricity Production Shares of Supplementary Energy Sources in South Africa from 2020 to 2022 27

1. Introduction

So far, in 2023, South Africans have been plagued by 3,305 hours of scheduled electricity cuts across the country (WellWellWell Investment, 2023). This practice, known as loadshedding, is the main symptom of the electricity crisis that has been burdening South Africa since 2007 (Akinbami, Oke & Bodunrin, 2021; IRENA, 2020). Loadshedding is implemented according to a rotational schedule to reduce demand on the electricity grid by temporarily cutting the power of different areas at a time (Department of Economic Development and Tourism, 2019, p.2; Roby, 2013). Since the electricity supply by the country's energy provider, Eskom, can no longer satisfy national demand (Inglesi-Lotz, 2022; Polokwane Government, n.d.; The Presidency Republic of South Africa, 2022a), loadshedding is the measure of last resort to relieve pressure from the electricity grid and prevent nation-wide blackouts.

Although loadshedding is common in Sub-Saharan Africa (Trace, 2020), the South African electricity cuts are far worse than elsewhere. Since a stable energy supply is vital for functional modern societies (Nowakowska & Tubis, 2015), the impact of worsening loadshedding (Roff et al., 2022) cannot be understated. Besides its destructive effects on South Africa's economy (Akpeji et al., 2020; Lenoke, 2017), the crisis harms social well-being (Maggot et al., 2022). In addition, frequent loadshedding is compounding other troubles, such as soaring unemployment, thus affecting the government's ability to reach its development goals (World Bank Group, 2022), particularly in light of the ongoing Covid-recovery (National Treasury Republic of South Africa, 2022). Altogether, the electricity crisis damages South Africa's development through different mechanisms, making it vital to mitigate loadshedding as quickly as possible.

At the same time, South Africa is facing aggravating effects of the climate crisis (Aliyu, Modu & Tan, 2018; USAID, 2022). Yet, despite its government's commitment to the Paris Goals (Hanto et al., 2022a), the country's electricity generation is primarily based on coal (Ayamolowo, Manditereza & Kusakana, 2022). Different studies (Roff et al., 2022; Steyn et al., 2022; World Bank Group, 2022) have suggested that renewables help mitigate climate change and present the most cost-efficient solution to South Africa's electricity crisis. After all, additional generation capacity decreases the strain on existing power plants. Due to that, the government initiated several programmes, namely the Independent Power Producer Procurement Programmes, to drive green generation (Baker, 2017a).

Overall, South Africa is making efforts to mitigate its crisis. Still, the question of whether these efforts are leading to results remains. This thesis explores how the electricity crisis has pushed renewables within the government-driven energy procurement programmes. It is doing so by establishing a theoretical framework based on prior theory and findings and then testing whether the concept of energy security driving renewable energy applies to South Africa's case. A second research focus lies on the mechanisms impacting progress in the development of renewables. Considering the detrimental electricity crisis, it is crucial to understand which factors hinder advancements in non-fossil deployment. Such knowledge benefits South African policymakers and civil society, who push for low-carbon transformations and swift mitigation of loadshedding but are often powerless against the national coal lobbies (Hanto et al., 2022b). Likewise, this study adds to an existing base of academic literature on the applicability of the energy security framework to specific cases. Therefore, this thesis aids the filling of knowledge gaps by answering these two research questions:

Main question: How has the current electricity crisis in South Africa affected the development of renewable energy within the Independent Power Producer Procurement Programmes?

Sub-Question: Which factors are impacting progress in the development of renewable energy in South Africa?

1.1. Scope

This research focuses on one side of the relationship between energy security and renewables, not including the effects of green energy sources on energy security. That is because South Africa wants coal-fuelled electricity to continue to dominate the sector and only considers renewable energy a supplement to existing generation capacity, as shown by the subsequent analysis. Thus, energy security concerns regarding renewables' volatility are secondary in this thesis. Nevertheless, they are examined as a factor that could impact the extent to which renewables are affected by the electricity crisis.

Moreover, the research excludes small-scale renewable projects, also called embedded generation, despite the recent rise in generation from those (Terblanche & Radmore, 2023, p.1). Considering the high costs of such private measures (Briers, 2022), embedded generation cannot present a socially sustainable solution for a highly unequal country like South Africa, justifying the focus on government-driven programmes. Additionally, projections of South Africa's energy mix with hypothetical 100% renewables show the significantly higher potential of large-scale solar and wind generation (Statista, 2015).

Experts have also argued that the Independent Power Producer Procurement Programmes may be South Africa's best chance for increased renewables (Steyn et al., 2022). Yet, this does not mean these programmes fulfil their potential or even generate positive change. Consequently, this study explores renewables' overall development rather than only capacity or generation. This way, planned efforts to increase renewables are included, thus capturing potential narrative changes by policymakers.

1.2. Outline of the Thesis

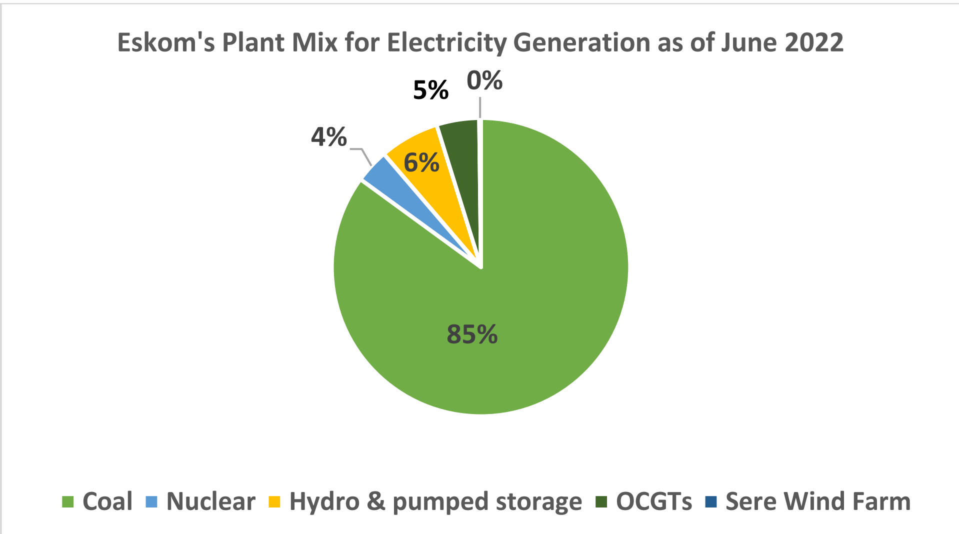
First, *Section 2* provides the background of the research problem by outlining South Africa's electricity sector and its ongoing crisis. This is followed by *Section 3*, which establishes the concept of energy security as a driver for renewable energy by reviewing academic theory and findings. Moreover, it outlines the research's analytical framework of energy security that applies to South Africa's energy crisis. *Section 4* explains the data and method of this thesis, and *Section 5* comprises the topic's analysis and findings. Then, these results are discussed in *Section 6* and lastly, the research concludes by answering the research questions and outlining implications as well as future research avenues in *Section 7*.

2. Background

2.1. South Africa's Electricity Sector

South Africa's electricity sector is heavily dominated by the country's state-owned electricity utility Eskom. The public company generates 90% of South Africa's electricity (Eskom, 2022a, p.1) and owns the national grid (IRENA, 2020, p.14), thus holding a monopoly on the transmission and distribution of electricity in the country. *Figure 1* shows Eskom's plant mix from which electricity is generated. It is visible that the utility's capacity is almost entirely reliant on coal as 85% of installed capacity originates from 15 high-volume coal plants (Eskom, 2022a, p.1). In addition to that, Eskom generates 11% of its electricity through hydro, pumped storage, and open-cycle gas turbines (OCGTs). These quickly provide additional generation when the coal baseload cannot meet peak demand (Eskom, 2022a). Further, Eskom operates one renewable energy project, the Sere Wind Farm, with a capacity of 100 MW (Eskom, 2022a, p.1), that barely contributes to the overall plant mix, though, as *Figure 1* shows.

Figure 1: Eskom's Plant Mix for Electricity Generation in South Africa, as of June 2022



Data obtained from Eskom, 2022a

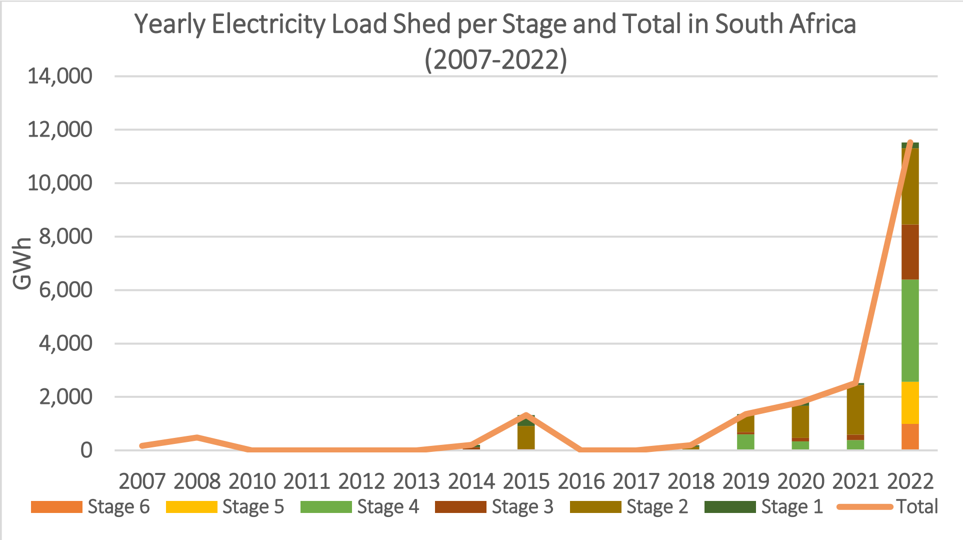
Due to Eskom's monopoly and the dominance of coal-fuelled generation, South Africa's coal use in the electricity sector is around 40% higher than the average among African nations (Statista, 2023, p.94). This coal dependence is based on its natural abundance, making it a relatively cheap energy source in South Africa (Cohen, 2021). Thus, when the national electricity demand began rising in the mid-20th century, there was an upsurge in the construction of new coal power plants (Kamanzi, 2021, p.12). This investment boom initially resulted in a medium-term overcapacity of the national grid (Eberhard, Kolker & Leigland, 2014, p.13) since added generation capacity grew faster than demand.

Although the 1980s saw a global shift towards energy sector liberalisation, South Africa's political and economic isolation during Apartheid led to Eskom retaining its monopoly position (Baker, 2017a, p.103). When the Department of Mineral Resources and Energy's (DMRE) White Paper on Energy Policy (1998, p.41) established that national electricity demand would outgrow supply by 2007 if no further generation capacity was developed, this did not result in additions to the power grid. Since the White Paper suggested opening the electricity market to private actors, lobbying efforts of Eskom and the coal mining industry (Kamanzi, 2021, p.21) resisted any changes to the power sector. Baker (2017a, p.106) mentions another reason behind the inaction, namely the government forbidding Eskom from constructing new power plants to open the way for private actors. However, IPPs could not enter the sector due to the utility's resistance to surrendering its monopoly, leading to a stillstand in building much-needed power plants. That highlights the lack of South Africa's regulatory capacity, which *Section 6* discusses further. Consequently, private developers still lacked policy-related incentives and clarity, impeding them from entering the national electricity market (Phaahla, 2015). As a result, South Africa's electricity reserves had dropped significantly by the early 2000s (Eberhard, Kolker & Leigland, 2014).

2.2. The Electricity Crisis

In 2007, as predicted by the White Paper in 1998, the lack of action to increase South Africa's electricity generation capacity culminated in an electricity supply crisis which presented itself in loadshedding (IRENA, 2020, p.44). The real trouble, however, only began in 2019 when power cuts became a common occurrence, as *Figure 2* shows. Loadshedding's intensity varies as there are eight stages depending on the extent of insufficient electricity generation. Each level is equal to 1,000 MW of load shed (Department of Economic Development and Tourism, 2019, p.2) so at stage two there would be 2,000 MW of lacking supply. According to George Municipality (2023), even stage two can result in four hours without electricity for the affected areas. These levels are not implemented in order but solely based on the extent of exceeding demand, so stage two can occur without stage one happening before. *Figure 2* depicts the amount of GWh that was shed since the beginning of the electricity crisis. It becomes evident that the electricity supply shortage worsened over the past two years due to the extent of power cuts in 2022, especially compared to 2021. In 2023, loadshedding has become a daily occurrence for the citizens of South Africa (WellWellWell Investment, 2023), indicating that this coming year will be even worse.

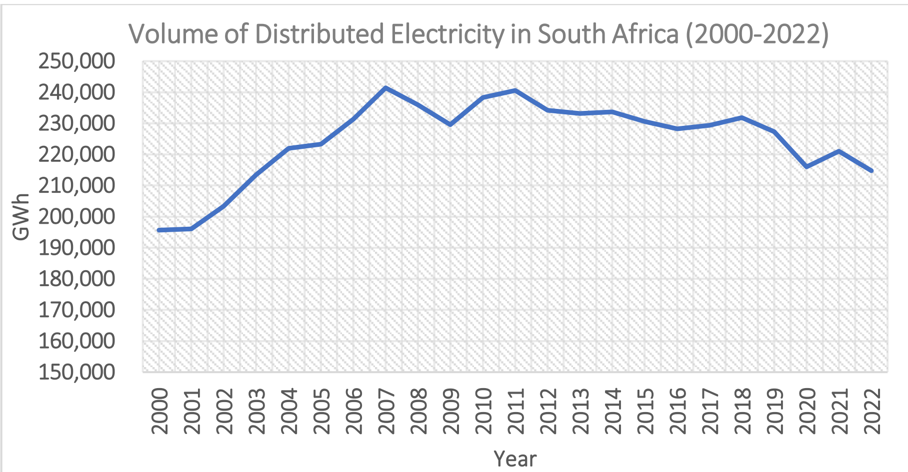
Figure 2: Yearly Loadshedding in South Africa per Stage and in Total in GWh



Data obtained from Calitz & Wright, 2019, p.18, 2020, p.18, 2021, p.207; Pierce & Ferreira, 2022, pp.9–10, 179; Pierce & Le Roux, 2023, pp.8–12, 110–118

While some government documents (Polokwane Government, n.d.) claim that the electricity crisis emerged as a result of Eskom's capacity being unable to keep up with rising demand through economic growth, this is not the whole picture. *Figure 3* shows the development of distributed electricity in South Africa since 2000. It demonstrates an absolute reduction in the electricity supply since loadshedding began in 2007. Therefore, the issue is not just lacking growth of generation but rather shrinking capacity, which Akinbami, Oke and Bodunrin (2021) also argue. The decrease in electricity supply is due to the average age of Eskom's plant fleet since most stations were built in the 1960s-70s. Hence, many plants have now reached or are nearing their end-of-life, leading to many breakdowns, unplanned maintenance (Department of Economic Development and Tourism, 2019) or shutdowns (Eskom, 2022b).

Figure 3: Distributed Electricity in South Africa's Grid from 2000 to 2022

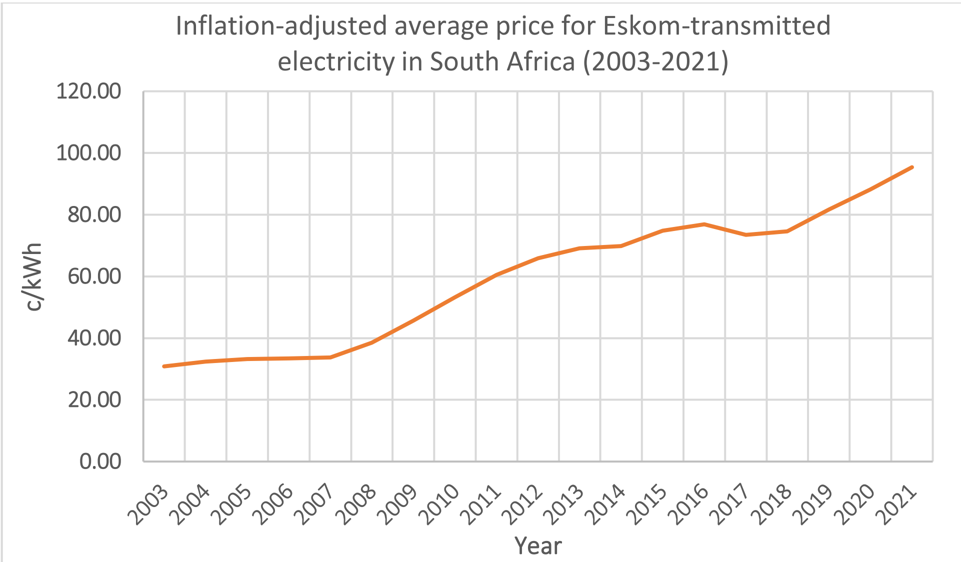


Data obtained from Statistics South Africa, 2003, p.6, 2008, p.5, 2013, p.4, 2018, p.4, 2023, p.4

Eskom's poor fleet performance, lacking success in procuring sufficient additional generation capacity (Roff et al., 2022) and mismanaged investments (Nowakowska & Tubis, 2015) created a vicious circle for the national power system. Capacity is going offline due to system failures which require emergency repairs, putting additional strain on the remaining functioning power plants. Consequently, there is no time to take them offline for necessary maintenance to prevent breakdowns in the first place (Briers, 2022). Furthermore, Eskom has often been associated with corruption scandals, employee negligence and sabotage through theft (Labuschagne, 2022; MyBroadband, 2018), which affect the state utility's ability to end loadshedding.

South Africa's current power sector can no longer provide reliable electricity at an affordable price (World Bank Group, 2022). That is the second dimension of the energy crisis, depicted in *Figure 4*. One can see that the average between all tariff groups sharply increased after 2007, the beginning of loadshedding, creating a 200% rise in inflation-adjusted prices until 2021. This price hike is explainable by Eskom's inefficient management and overspending on coal plant construction delays, which led to the company's indebtedness (Kamanzi, 2021; Roff et al., 2022). A Statistics South Africa Report (2022, p.4) shows that South Africa's electricity sector recorded losses of around 17.8 billion Rand in 2021, having reached a level that is impossible to pay off for Eskom (Businesstech, 2022).

Figure 4: Inflation-adjusted Average Prices for Eskom-transmitted Electricity in South Africa from 2003 to 2021



Note: Average price calculated between all tariff groups, i.e., local authorities, residential, commercial, mining, agriculture and traction. Own calculations and adjusted for inflation using inflation-adjusted value=actual value/index value.
Data obtained from Eskom, 2023a; World Bank Open Data, 2023

Considering the importance of energy for societal and economic life (Lenoke, 2017), it is unsurprising how detrimental the electricity crisis has been. There have been several protests since the beginning of 2023 as a public response to loadshedding's widening impact (AfricaNews, 2023; Rall, 2023; Steenkamp, 2023), leading to further disruptions of public life. Akpeji et al. (2020) highlight how damaging chronic electricity supply issues are for society and the economy because they contribute to lost production and rising unemployment (Roff et al., 2022) as well as social losses since electricity access is central in people's private and professional lives (Nowakowska & Tubis, 2015).

Unfortunately, it does not seem like South Africa's electricity crisis will end anytime soon. While Eskom expects loadshedding to continue at lower stages until 2025 (McLeod, 2023), the government aims to implement so-far unspecified measures to strengthen the electricity supply even earlier (Reuters, 2023a). Yet, energy experts forecast the opposite, particularly with upcoming demand peaks in the winter months (Businesstech, 2023). The expected further recovery of the electricity demand after the Covid-19 pandemic (International Trade Administration, 2021) and the increasing need for maintenance of Eskom's plants (Hypertext, 2022) make it quite likely that loadshedding in 2023 will again be worse than last year. That is why Steyn et al. (2022) stress that drastic action must be implemented as soon as possible.

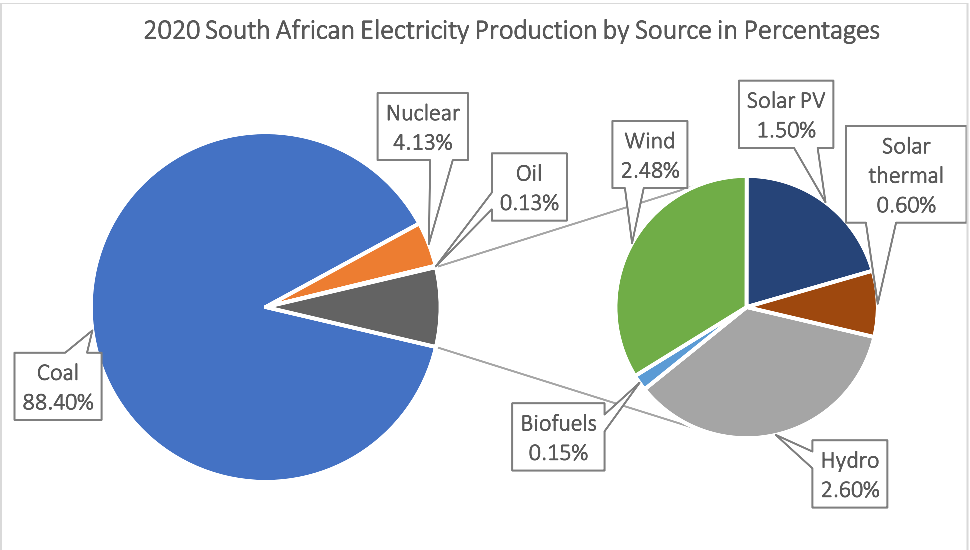
2.3. Mitigation of the Electricity Crisis

To mitigate South Africa's electricity crisis, building new generation capacity is inevitable (IRENA, 2020; Roff et al., 2022, p.1), especially considering the aforementioned problems with Eskom's production. After all, even the newly commissioned coal plants Medupi and Kusile have experienced considerable construction delays and low generation reliability (BizNews, 2023; Igamba, 2023). Consequently, in 2019, the government announced plans to unbundle Eskom, which would entail splitting the utility into three separate companies for generation, transmission and distribution (Terblanche & Radmore, 2023, p.37). Many experts argue that unbundling, creating a competitive energy sector, would partly solve the deeply-ingrained issues at the power utility (EYGM, 2021, p.13; Morris & Martin, 2015, p.68). Since no serious progress was made in this regard, though, it remains crucial to diversify the electricity sector (Hanto et al., 2022b) by opening it to more reliable energy producers and sources.

That is where Independent Power Producers (IPPs) come into play. These companies are founded by different shareholders, such as South African industrialists, local community representatives and foreign investors, to build and operate power plants (IPP Office, 2023a, p.7). This private generation is independent of Eskom but sold to the utility for transmission into the national grid (IPP Office, n.d.). According to Baker (2017a, p.102), this slight opening of South Africa's electricity market constitutes a significant step towards energy sector liberalisation. As such, a separate entity, the IPP Office, manages the procurement of IPP projects (IPP Office, 2023a) rather than Eskom.

South Africa established several IPP programmes, two of which focus on renewable energy generation. Renewables present the most promising mitigation strategy for the electricity crisis, particularly considering the country's high natural potential for wind and solar (Nhede, 2022). Even Eskom's former CEO admitted that ending loadshedding is best done through renewable energy (Whitehouse, 2022). Moreover, renewables are inevitable for the government to meet its climate targets (UNEP, 2022), potentially making new procurement of coal-fuelled capacity stranded investments in the long run. As *Figure 5* shows, there is a small share of renewable energy in the national grid. When comparing this and Eskom's plant mix in *Figure 1*, it becomes evident that most renewable energy in South Africa is generated by IPPs.

Figure 5: South Africa's Electricity Production by all Power Producers by Source for 2020



Data obtained from Ritchie & Roser, 2022

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) was established in 2011 to replace a former feed-in tariff (Baker, 2017a). The REIPPPP encompasses large-scale utility generation projects for onshore wind, solar photovoltaic (PV), concentrated solar power (CSP), small hydro and biofuels (Baker, 2017a, p.102). It is a competitive bidding system that enables tariff reductions for renewable energy. After bid submissions, the IPP office selects preferred bidders based on their rankings in different categories (Eberhard & Naude, 2016). Moreover, every IPP project must fulfil economic development criteria, such as ownership of local communities or job creation, to be eligible for the REIPPPP (Eberhard & Naude, 2016, p.9). The chosen preferred bidders then sign 20-year government-backed power purchase agreements (PPAs) with Eskom since the utility has to purchase the privately-generated renewable energy (Ayamolowo, Manditereza & Kusakana, 2022).

While the Risk Mitigation Independent Power Producer Procurement Programme (RMIPPPP), established in 2020, is structured identically to the REIPPPP, the former is not fixated on renewable energy sources. Since the RMIPPPP was launched to bridge the 2,000 MW supply gap in South Africa's electricity grid (Kamanzi, 2021, p.28), it focuses on combining different technologies to achieve dispatchable and flexible generation (Burger, 2022).

Apart from the government-driven renewables programmes, the private sector's efforts towards energy diversification have also been accelerated by the electricity crisis. Eskom, for instance, has begun to restructure phased-out coal plants for renewable energy generation (Eskom, 2022b). On the other hand, households and companies are increasingly constructing small-scale embedded generation to reduce their dependence on the state utility's unreliable electricity supply (Hanto et al., 2022a, p.307). These developments are supported by the government, which amended electricity regulations to remove barriers to self-generation, resulting in the registration of around 1,800 MW of self-generated electricity with the regulatory authorities (Terblanche & Radmore, 2023, p.1). Furthermore, businesses and individuals use batteries or generators (AfricaNews, 2021; Briers, 2022) to deal with the ramifications of loadshedding. While this is a viable strategy in the short run, its financial costs and environmental effects should not be underestimated, according to an IFC report (2019). Consequently, small businesses and less-affluent families cannot afford such mitigation strategies (Kamanzi, 2021, p.27), highlighting the social justice perspective of the electricity crisis.

3. Literature Review and Theoretical Framework

Only some literature applies a long-run perspective to the South African renewable energy capacity developments and relates it to loadshedding, partly due to the crisis' recency. Still, concepts concerning the general relationship between energy security and renewables exist and are reviewed in *3.1*. Based on those, an energy security framework regarding South Africa's crisis is formulated.

3.1. Energy Security Framework

Recently, the topic of energy security climbed back to the top of the global agenda due to geopolitical conflicts and rising fossil-fuel prices (UNEP, 2022). While Elbassoussy (2019) argues that European energy security is currently threatened due to its reliance on Russian fuel, Bassetti (2022) considers this situation an opportunity to overturn the existing energy systems towards green generation. Therefore, energy crises can represent drivers for long-term change if their transformative potential is harnessed.

The concept of energy security first emerged during the 1970s oil crisis (Bassetti, 2022; Jakstas, 2020, p.100) since this required a new understanding of energy supply and the factors affecting it. Since then, the framework has developed into a complex of different perspectives. Something most definitions share, though, is the inclusion of supply security through energy availability and affordability.

Among the examined papers, Chu et al. (2023, p.5) apply the narrowest definition of energy security by fixating it on a country's vulnerability to the volatility of global energy markets. They measure the concept through energy expenditures, remaining reserves, import dependence and other factors. Contrarily, Dahlan et al. (2022, p.45) focus on the so-called four A's: availability, accessibility, affordability and acceptability of national energy supply and sources. Hence, they still incorporate similar dimensions as Chu et al. (2023) but expand the definition towards a more social perspective.

Ang, Choong & Ng (2015, pp.1081–1091) review over 80 energy security definitions. Their results confirm the existence of broad and diverging dimensions of energy security, consisting of availability, adequate infrastructure, prices, societal consequences, environmental considerations and energy efficiency. Moreover, they stress the importance of energy mix diversity for most of these aspects. By highlighting the diversity of the framework, the authors argue that energy security must remain highly contextual as the applied definition has to fit the respective national circumstances.

Like the other authors, Jakstas (2020, p.101) argues for the need to account for a country's surroundings when defining frameworks because energy importers' perspectives differ from exporters' needs. Whereas the latter must secure access to electricity customers abroad, importers are concerned with ensuring uninterrupted supply, diversification and energy efficiency. Additionally, Jakstas underlines the framework's complexity due to its far-reaching implications for society and the economy, which intersects with the trilemma between attempting to achieve the energy sector's security, competitiveness and sustainability simultaneously (Ang, Choong & Ng, 2015, p.1090). The conceptualisation applied to South Africa's case is established in *Section 3.2.*

3.1.1. The Role of Energy Security for Renewable Energy

There is much literature about different drivers of renewable energy deployment, which shows that not just sustainable policymaking affects renewables (Marques & Fuinhas, 2011, p.6878). Instead, energy insecurity is often identified as another impactful factor (Ibrahiem & Hanafy, 2021; Jakstas, 2020; Ndlovu & Inglesi-Lotz, 2019; Ölz, Sims & Kirchner, 2007). After all, renewables offer efficient pathways towards several dimensions of energy security, thus being crucial for mitigating power crises.

Despite their potential benefits, renewables bear one major flaw with their volatility from changing weather conditions (Cergibozan, 2022; Ölz, Sims & Kirchner, 2007). Additionally, high levels of renewable generation raise countries' energy insecurity since unforeseeable production levels from non-fossil sources could exceed demand and overload grid infrastructure (Jakstas, 2020, p.109). Therefore, Ölz, Sims and Kirchner (2007, p.9, 36) argue that, for maximum energy security, renewables should not entirely replace traditional power sources. Generally, though, they explain that supply, financial and environmental risk structures differ between fossil and non-fossil energies. Hence, even if renewables pose new risks, a highly diversified power sector promises the highest possible resilience.

Overall, green energy sources secure countries' energy supplies, particularly due to the diversification of the plant mix through renewables (Ndlovu & Inglesi-Lotz, 2019, p.16). Combining different renewable power sources even allows for dispatchable generation, so the potential of a constant and controlled electricity supply which can mitigate supply disruptions (Ölz, Sims & Kirchner, 2007, p.9). Moreover, according to Marques and Fuinhas (2011, p.6885), green technologies reduce import dependence since they are easily-accessible domestic resources, at least once they are built as their construction often relies on foreign technologies. Lastly, renewables contribute to supply security as they are not finite resources (Cergibozan, 2022) so governments do not need to fear ending fossil reserves.

Another mechanism through which green technologies support energy security is affordability. Cergibozan (2022), as well as Ölz, Sims and Kirchner (2007, p.36), argue that renewables are less threatened by price volatilities, making them some of the cheapest energy sources in South Africa (Eberhard & Naude, 2016, p.2). After all, they are usually not integrated into global energy markets to the same extent as fossil fuels, although this differs between energy markets. The Russian war, for instance, resulted in exploding oil and gas prices, which hurts Europe's energy security, according to Bassetti (2022).

Although environmental concerns may not be the most pressing issue for governments facing power supply crises, the positive impacts of renewables on emission reductions and long-run sustainability cannot be understated (Cergibozan, 2022; Marques & Fuinhas, 2011, p.6885). As established in the prior section, sustainability is a central component of energy security frameworks (Ang, Choong & Ng, 2015). This matters because sustainability considerations may increase the public's acceptability of the energy sector, which Dahlan et al. (2022) recognise as crucial.

3.1.2. Empirical Findings: Energy security as a driver for renewables

This section reviews empirical findings regarding the impact of energy insecurity on the deployment of renewables. While the influence of renewables' volatility is not spotlighted, the effect of diversification through renewables on energy security is considered. Ibrahiem and Hanafy (2021, p.670) stress that energy security is a relevant driver for renewables despite empirical findings producing different results. Lucas, Francés & González (2016) support this notion by showing the situational dependence of the relationship between energy security and non-fossil sources. Still, their analysis of EU countries finds a correlation between plans to increase energy security and renewable energy deployment. Likewise, Pignatti (2023) presents that the correlation between energy security concerns and green technologies applies to Georgia. Hence, the analyses support the theoretical framework outlined previously and underline the importance of situation-related concepts.

Others, however, present a more ambivalent picture of the notion. While Ellerbeck (2023) explains how the EU has accelerated the green transition due to the Russian fuel supply crisis, Bassetti (2022) argues that some governments facing the same circumstances build more fossil capacity instead. In contrast, Popp, Hascic and Medhi (2011) identify emission reduction strategies rather than energy security concerns as the driver of renewables. Therefore, their results counteract most findings of energy security as the main driver for green electricity. Nevertheless, Morris and Martin (2015, p.6) show that in South Africa, power security mitigation matters considerably more than climate change. In summary, the applicability of the energy security framework diverges with national circumstances, such as natural abundance or the government's goals for the power sector.

3.2. Energy Security in South Africa's Electricity Crisis

As the previous sections underlined, it is of utmost importance to adjust the energy security framework to the specific case, so South Africa in this thesis. The IEA (2023, n.p.) defines energy security as the "uninterrupted availability of energy sources at an affordable price". Long-term energy security, namely a stable supply balanced with environmental and economic indicators, differs from short-term needs, which focus on the ability to quickly adjust to supply-demand situations (IEA, 2023). *Section 2* shows that both dimensions are currently threatened by South Africa's electricity crisis. According to South Africa's Integrated Resource Plan (Mantashe, 2019, p.11), the main issue of national energy security revolves around the necessity to keep an electricity reserve margin that rises with economic growth, allowing for further unhindered development, which is currently not given in the country either.

Moreover, Dahlan et al.'s (2022, p.44) four A's of energy security fit South Africa's context. Reliable availability of electricity is clearly not given in the current loadshedding crisis. Likewise, affordability is threatened as the price hikes in *Figure 4* depict. Although protests against loadshedding (AfricaNews, 2023) show a momentarily lacking acceptability of the electricity regime, South Africans seem to accept the underlying energy sources due to the comparatively small outroar over the country's coal dominance (Burkhardt, 2023). Municipal policymakers, however, are increasingly pushing for independence from Eskom's coal power to procure their own renewable electricity (Dana, 2021; Hill-Lewis, 2022), which shows a divide in the acceptance of South Africa's energy regime. Contrastingly, accessibility is not a large issue since national electrification rates are high (International Trade Administration, 2021). Electricity sources' accessibility is not threatened either because the coal (Cohen, 2021) and renewables abundance (Doorga, Hall & Eyre, 2022) allow for independence. Although the technologies for renewable generation usually come from abroad, South Africa has created sustained interest in their IPP programmes (DMRE, 2021a), so there is currently no need to fear lacking access to technology inputs.

Overall, the electricity crisis in South Africa is an example of energy insecurity. Resulting from Eskom's lacking capability to provide sufficient electricity supply, the country is suffering from frequent loadshedding, exploding power prices, insufficient infrastructural developments and lacking long-run sustainability. Even though South Africa is exposed to problems faced by energy importers, it exports twice as much electricity and 26 times more coal than it imports (DMRE, 2019a, 2019b). These exports generate considerable revenue for the country (Reuters, 2023b), which explains why they continue despite frequent loadshedding. Consequently, South Africa should be concerned with securing electricity customers abroad and ensuring an uninterrupted, diversified energy supply, according to Jakstas' framework (2020, p.101).

This thesis analyses whether South Africa's energy insecurity drives renewables by applying different dimensions of the established energy security framework. Following this brief analysis and *Section 3.1*, *Table 1* shows the dimensions of South Africa's electricity crisis that may push renewables in the country and are therefore discussed in *Section 6*.

Table 1: Energy Security Dimensions within South Africa's Electricity Crisis

A)	Short-term availability of undisrupted electricity
B)	Affordability of electricity
C)	Acceptability of energy regime
D)	Long-run sustainability of the electricity sector
E)	Infrastructural foundation to support stable electricity supply

3.3. Mitigating South Africa's Electricity Crisis with Renewables

Despite fossil generation likely still composing most of South Africa's electricity production by 2030, an increase in the renewable electricity mix share is expected (IEA, 2022a, p.90). IRENA (2020) and World Bank Group (2022) consider this green transition to be driven by the country's energy supply issues. Additionally, IRENA (2020, pp.55) explains that renewables require more labour since prior REIPPPP projects created more jobs than initially expected. That can help South Africa mitigate its electricity and the interrelated unemployment crisis.

Nepal constitutes another example of a country facing loadshedding managed to eradicate supply disruptions in 2018 after reforms from the 90s finally bore fruits. Particularly, the introduction of IPPs and overturning of the power sector secured the national electricity supply, according to the World Bank (2019). Yet, Poudyal et al. (2019) argue that the country's insufficient renewable deployment prevents it from reaching energy independence. While Nepal's case suggests that similar policies could be successful in South Africa, both short- and long-term solutions must be considered since Nepal's mitigation strategies only succeeded after two decades.

Several studies have identified South Africa's extremely high potential for renewable energy deployment due to the natural abundance of green electricity sources. Doorga, Hall and Eyre

(2022, p.17) analyse African sites for utility-scale onshore wind and solar PV. They find that South Africa to be amongst the most favourable nations on the continent. Specifically, they regard it as the best country for onshore wind and second-best for solar generation. South Africa's great potential for wind-fuelled electricity is confirmed by several assessments due to suitable wind speeds (Akinbami, Oke & Bodunrin, 2021, p.5084). Since most of South Africa experiences over six hours of sunshine daily, its solar potential is high as well (Akinbami, Oke & Bodunrin, 2021, p.5087). Yet, Aliyu, Modu and Tan (2018) stress the urgency of fixing the issue of storing generated solar power to utilise its full potential.

Despite the high geographic potential for renewables in South Africa, costs must be considered too. Walwyn and Brent (2015, pp.391–399) argue that the price of non-fossil electricity should continue to decrease as it has done so since the 2000s. Especially solar PV is becoming cheaper due to Swanson's Law, according to which costs drop 20% with each doubling of cumulative volume, as the authors explain. Apart from direct electricity production costs, renewables also bear associated infrastructural expenditures. Overall, South Africa's sustainable transition would be immensely expensive but Morisset and Salto (2022) suggest that the financial and social gains from eradicating loadshedding would outweigh these costs. Calculations from Roff et al. (2022, p.24) furthermore show that savings from ending the electricity crisis more than compensate for the costs of adding renewable generation capacity to the grid. Thus, South Africa's green power transition is economically justifiable.

Considering these useful preconditions, Roff et al. (2022, pp.8-18) explore how feasible a timely solution to the energy crisis is. Their calculations show that an added 5 GW of operational wind and solar capacity could have prevented 96% of loadshedding in 2021. Hence, they argue that green technologies reduce power sector risks by increasing overall grid reliability. Their analysis concludes that mitigating loadshedding through renewables is feasible since a diverse portfolio of non-fossil sources can generate sufficient power during peak loadshedding hours.

South Africa has slowly started its green transition with the REIPPPP, which is globally regarded as a well-designed policy (Aliyu, Modu & Tan, 2018; Baker, 2017a). Eberhard (2013, p.5) evaluates the benefits of the programme and highlights its efficient procurement process, extensive local development objectives and sufficient governmental support. The IEA (2022a, p.172) also emphasises the REIPPPP's de-risking of investments into renewables due to the programme's financing mechanisms, creating the basis for the popularity among international energy developers (Baker, 2017a, p.109).

Although the REIPPPP is lauded for its design, Steyn et al. (2022) consider South Africa’s actions insufficient to tackle the electricity crisis. Literature has established explanations for the lacking progress towards ending loadshedding, which can be separated into technical dimensions (Akinbami, Oke & Bodunrin, 2021; Eberhard, 2013) and political-economy approaches (Baker, 2017b; Hanto et al., 2022b). From a technical point of view, the greatest hindrance to solving South Africa’s electricity crisis is insufficient grid capacity. As grid connection is imperative for large-scale energy projects, lacking infrastructure results in power losses (Akinbami, Oke & Bodunrin, 2021, p.5084).

The political-economy dimension is highly impactful for South Africa as well. The Minerals-energy complex (MEC) is usually a point of departure for that. Baker (2017b, p.373) defines the MEC as a “system of production and consumption based on the country’s historical dependence on cheap and abundant coal supplies”. Since Eskom entirely controls South Africa’s electricity transmission and most of the distribution and generation, it holds an enormous influence. Likewise, the interests of the mining sector, which consumes a large share of the country’s power while also supplying the majority of Eskom’s coal, intersect with the state utility’s concerns, hence creating a strong lobby (Hanto et al., 2022a; Lawrence, 2020a).

Overall, this literature review shows that there is significant background on the impact of energy insecurity on renewable developments, which was considered for the framework of South Africa’s electricity crisis. Most findings point towards the importance of energy security as a driver for renewables but *Section 5* establishes whether this applies to the case at hand, taking the mentioned barriers and supporting factors to mitigation into account as well.

4. Data and Method

4.1. Research Design

To answer the research questions, this thesis employs a mixed-methods case study. That is the most suitable approach as the research's objectives require an in-depth analysis of events and developments surrounding a specific topic (Creswell, 2014, p.30; Odell, 2001, p.170), namely the electricity crisis, its related energy insecurity and IPP projects. By utilising this method, I can gain a broader understanding of diverging perspectives regarding the issue at hand. If applying a solely quantitative methodology, I could not conduct a sufficiently detailed descriptive analysis or understand the mechanisms behind the observed trends due to the abundance of data observations (Creswell, 2014, pp.16–17). Alternatively, employing only qualitative data cannot facilitate a holistic understanding of the changing renewable capacity since it neglects quantitative developments (Creswell, 2014, pp.16–17). Therefore, I chose to not limit myself to either quantitative or qualitative methodologies. A mixed-methods approach allows for a comprehensive understanding of the research questions (Cook & Kamalodeen, 2019, p.30; Creswell, 2014, p.4). After all, it can adequately grasp the complexity of the economic, political, and technical dimensions of renewable energy generation in South Africa and objectively examine how IPPs have developed through the electricity crisis.

4.2. Data Collection

4.2.1. Quantitative Data

The secondary quantitative data was collected from several sources. The first dataset was compiled from yearly releases on utility-scale power generation by the Council of Scientific and Industrial Research (CSIR). I used their 2022, 2021, 2020 and 2019 reports to generate a database that includes statistics on South Africa's generation capacity by source, annual production and loadshedding. This dataset is used to analyse progress in renewable deployment and to establish the electricity crisis in the background section.

My second database provides an overview of all REIPPPP and RMIPPPP projects, including capacity, project status and applied technology. The underlying data was collected from reports published by the IPP Office and the Department of Mineral Resources and Energy. To ensure that the given information was still up to date, I supplemented the database with recent media statements. The IPP Project Database is used for analysing trends in renewable generation in South Africa. The full database is depicted in *Appendix A*.

Lastly, I use data from Eskom's Data Portal, which offers in-depth information on electricity production in South Africa's grid and is used to analyse the renewable IPP generation as a share of Eskom's production. Although this data is only accessible for the past five years, I can supplement the missing years with the CSIR dataset to provide a reliable overview since 2013. Additionally, I utilise databases from other institutions, like 'Our World in Data', to provide background information as well as governmental reports for numerical material that could not be obtained otherwise.

4.2.2. Qualitative Data

I compiled a variety of primary and secondary qualitative data. The primary qualitative data mainly consists of reports and policy documents from South Africa's government, the IPP Office, Eskom and international organisations. Analysing this type of data enables understanding the intent behind energy policy which can establish a relationship with the electricity crisis. These documents were initially collected based on a Database of African Renewable Energy Policies (Müller et al., 2020, pp.65–66) that provides an overview of policies in South Africa. Additionally, I compiled related reports by browsing the publications of the IPP Office, Eskom and South Africa's government to check for connections to my research topic. Furthermore, I complemented the qualitative content analysis with more recent newspaper or magazine articles, thus making them primary data sources. I chose data that records governmental action through media reports or offers expert opinions to cover topics my other primary sources did not.

The secondary qualitative data mostly consists of academic articles and books that were accessed through scholarly databases, such as ScienceDirect. This data is employed to supplement quantitative findings or strengthen the analysis' theoretical framework in the discussion. Moreover, I collected news and magazine articles as well as blog posts as secondary data sources. These provide the most current insights into South African developments, which primary reports or scholarly articles cannot contribute. By combining both types of qualitative data, I can complement established information from primary sources with up-to-date developments from secondary sources. That is crucial for understanding the relationship between the electricity crisis and renewable deployment, especially considering that loadshedding is an ongoing situation with constant policy evolution.

4.3. Methods for Analysis

The quantitative data is analysed descriptively through graphs and tables that were created using Excel and SPPSS. Such graphical analysis allows for thoroughly exploring long-run data to find patterns while presenting it informatively (Chambers, 2018, p.1). Through descriptive analysis, I can explore how South Africa's renewable generation capacity has developed since the crisis began and find trends in those developments. Where possible, I employ data observations starting in 2000 to understand how renewable capacity looked before the electricity crisis. Considering the energy security framework outlined in *3.1.2*, I analyse not just renewable generation but also how loadshedding has affected expenditures and infrastructural advancements.

To understand whether observed quantitative trends correspond to developments in South Africa's electricity crisis, I put the findings into context through qualitative analysis. Otherwise, I could neither test the applicability of the energy security framework as a driver for renewables nor answer my sub-research question. To do so, I utilise a content analysis approach. Thus, I analyse textual data by searching for emerging themes and patterns in the documents and relate them to each other, the quantitative findings and the existing theories from the literature review (Columbia University, 2016; Drisko & Maschi, 2015, pp.25–27). An overview of this analysis is provided in two summary tables in *Appendix C*.

4.4. Limitations of Research Design and Data Collection

This thesis analyses the relationship between the electricity crisis and IPP procurement of renewable energy. However, many drivers affect green transitions, such as the global trend towards low-carbon transformations to mitigate climate change (Shah & Solangi, 2019). Consequently, this analysis could overestimate the role of South Africa's electricity crisis as most national policies aim to secure the national energy supply with emission outputs being secondary factors. Still, by supplementing my quantitative findings with qualitative data and the energy security framework, I can establish limited causality. However, I must acknowledge that energy security is likely not the sole driver behind renewable energy developments. In my qualitative analysis I consider the impact of environmental concerns on energy policy in South Africa and compare it to energy security measures. In doing so, I aim to mitigate this limitation while taking a long-term perspective on drivers of renewables deployment.

A common drawback of case study research is the lacking generality and external validity of results (Odell, 2001, p.171). Especially because the framework of energy security and renewable developments is highly context-specific on national circumstances and applied concept definitions, as established in *Section 3.1.2*, this affects this research as well. Nevertheless, this thesis contributes analytical value since it does not test the theory's general validity but aims to show that certain concepts are applicable to broader circumstances. After all, this case study of South Africa is considerably more specific than many empirical reviews on energy security frameworks by analysing an explicit example of an energy crisis that contains less dimensions than other studies. Thus, this thesis produces generalisable results regarding the possibility of extending energy security frameworks to a broader group of cases.

Another limitation concerns the available data. Most quantitative and qualitative data derives from South Africa's government and Eskom. Considering both actors' interest in concealing the full extent of the electricity crisis, the data reliability may be questioned. To mitigate this and gain a relatively objective understanding of the developments surrounding the country's energy crisis, I supplement my analysis with scholarly findings, independent reports and media coverage. Moreover, the data sources been used by other researchers and institutes, implying that their reliability is sufficient for a holistic analysis. However, even if the data only presented lower bound estimates, this research's general implications and results would still hold. After all, this analysis does not attempt to assign numerical values to the relationship between loadshedding and renewable deployment but rather study its overall trends.

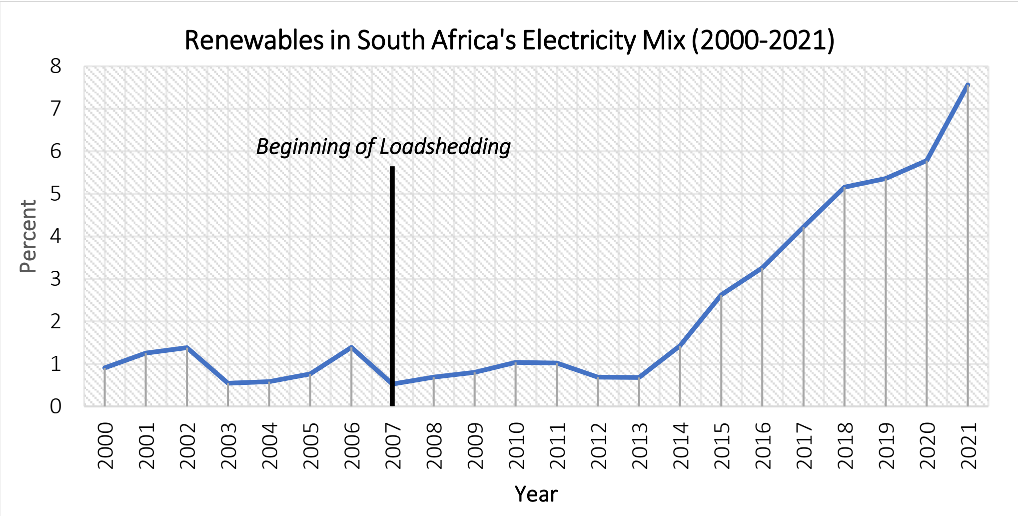
Lastly, it is impossible to establish a tight quantitative relationship between loadshedding and IPP developments since the REIPPPP and RMIPPPP were implemented after the crisis began. Thus, I cannot compare the programmes' contributions before and after loadshedding, although their implementation dates indicate a possible relationship. As a result, adding the qualitative dimension to the analysis is inevitable to confirm the connection between loadshedding and renewables in South Africa that quantitative trends may predict.

5. Analysis and Findings

5.1. Development of Renewables since the Electricity Crisis

To understand whether the electricity crisis affects renewables in South Africa, I first consider their overall development since loadshedding began. *Figure 6* shows the share of renewables in South Africa's electricity mix from 2000 to 2021. It suggests that the take-off of renewable electricity was in 2013. That is the year when the first REIPPPP generation became operational and coincides with the maximum time it takes to get capacity on the grid after the programme's initiation in 2010. Since then, the share of renewable generation has constantly risen, clearly highlighting the difference in pre-loadshedding levels to now.

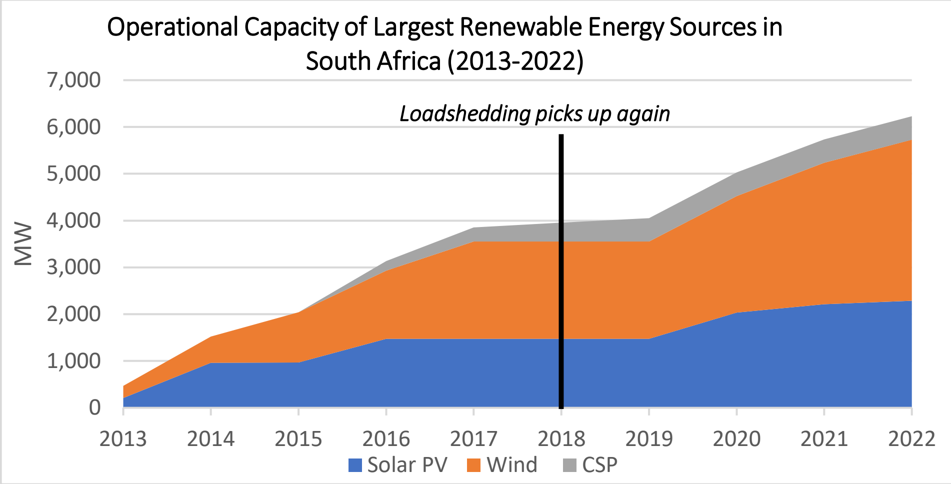
Figure 6: Share of Renewable Electricity in South Africa's Electricity Mix, 2000-2021



Data obtained from Ritchie & Roser, 2022

Since electricity shares are relative to other energy sources, it is crucial to study absolute capacities to get the whole picture of the ongoing trends. Hence, *Figure 7* presents the operational capacity of the main renewable energy sources in South Africa from 2013 to 2022. Other REIPPPP sources, like small hydro and biofuels, are excluded since their contribution is so small that their impact is negligible for this analysis (REDIS, 2022). Therefore, only wind, solar PV and CSP are included. Even in absolute terms, the renewables' capacity has risen from almost zero before 2013 to over 6,000MW in 2022. A further increase in the growth rate is visible in 2020. This timing corresponds with the time lag of constructing capacity after the second escalation of the loadshedding crisis in 2018, resulting in increased government action in fixing prior delays (The Presidency Republic of South Africa, 2022a, p.3).

Figure 7: Operational Capacity of Wind, Solar PV and CSP in South Africa, 2013-2022



Data obtained from Calitz & Wright, 2019, p.18, 2020, p.18, 2021, p.207; Pierce & Ferreira, 2022, pp.9–10, 179; Pierce & Le Roux, 2023, pp.8–12, 110–118

5.1.1. Overview REIPPPP

So far, the REIPPPP has generated seven bid windows (BWs) with 123 projects since its introduction in 2010. BW1 included the most projects, whereas the latest BW6 only comprised six, as *Table 2* shows. Therefore, the recent escalation of loadshedding in South Africa does not seem to have culminated in greater procurement through the latest bidding rounds of the REIPPPP, reasons for which are discussed later. Of the 123 projects, 71% are operational so far, 2.4% are in construction and the remaining 26% are in varying stages of the pre-construction process. That could indicate that many projects were procured in recent years, not leaving sufficient time to start construction. Yet, it is also possible that there have been years of delays in getting REIPPPP projects on the grid. Considering that all but one of the BW1-4 projects are operational or under construction, the latter seems less likely. The one BW3 project that has not reached financial close will never be completed due to financing issues (IPP Office, 2021, p.2).

Almost 90% of the REIPPPP projects employ onshore wind and solar PV, with the latest two bid windows solely including these technologies. The projects vary in size between 3.8 MW to 240 MW. Overall, the operational power plants have contributed almost 90 TWh of renewable electricity to South Africa's grid from 2013 to 2022 (own calculations based on CSIR data from *Figure 7*). In contrast, Eskom's coal plants produced almost twice as much in 2022 alone (CSIR data from *Figure 7*), underlining the REIPPPP's supplementary nature. Still, Gxasheka et al. (2023, p.8) find that REIPPPP plants produced around 50 times more power than non-renewable IPPs. Additionally, these plants generated more electricity last year than in 2021, which indicates increased production related to the worsening electricity crisis.

Table 2: Overview of Pertinent REIPPPP and RMIPPPP Statistics

REIPPPP Descriptive Statistics Overview *(Data obtained from SPSS Tabulations in Appendix B)*					
Number of Projects	123	Status of Projects			
BW1	28			Operational	71.5%
BW2	19			In construction	2.4%
BW3	17			Pre-construction stages	26%
BW3.5	2				
BW4	26				
BW5	25				
BW6	6				
Type of Technology	Biomass and gas	CSP	Wind	Solar PV	Small Hydro
BW1	0	2	8	18	0
BW2	0	1	7	9	2
BW3	2	2	7	6	0
BW3.5	0	2	0	0	0
BW4	1	0	12	12	1
BW5	0	0	12	13	0
BW6	0	0	0	6	0
Total	3	7	46	64	3
RMIPPPP Descriptive Statistics Overview *(Data obtained from RMIPPPP Database in Appendix A)*					
Number of Projects	11				
Total Capacity	1,9995.76 MW				
Status of Projects					
Preferred bidder	8 projects, 72.7%				
Financial close	3 projects, 27.3%				

5.1.2. Overview RMIPPPP

The RMIPPPP is a significantly smaller and newer programme than the REIPPPP and procured almost 2,000 MW, as *Table 2* shows. Only three of the eleven projects have reached financial close, so construction has not yet commenced, despite the requirement for preferred bidders to finish paperwork and begin construction by mid-2021 (DMRE, 2020a, p.11).

All RMIPPPP bids combine different technologies to allow for the most flexible generation that mitigates loadshedding as much as possible (DMRE, 2020b). Out of the eleven projects, all but three have renewable energy components to them. Particularly the combination of wind or solar PV with battery storage is central to the RMIPPPP's successful bids. This showcases the potential of green technologies as a supplement to fossil-based sources.

5.2. Impact of Energy Security on Renewable Energy in South Africa

Although the recently increased role of renewables in South Africa hints at a connection between the electricity crisis and renewable energy quantitatively, this must be further explored qualitatively. The first summary table in *Appendix C* depicts all analysis results of the main research question and shows the emergence of nine themes. These themes are presented in *Table 3* and analysed in detail in the coming section.

Table 3: Overview of Qualitative Analysis Results for RQ1 *(Source: Appendix C)*

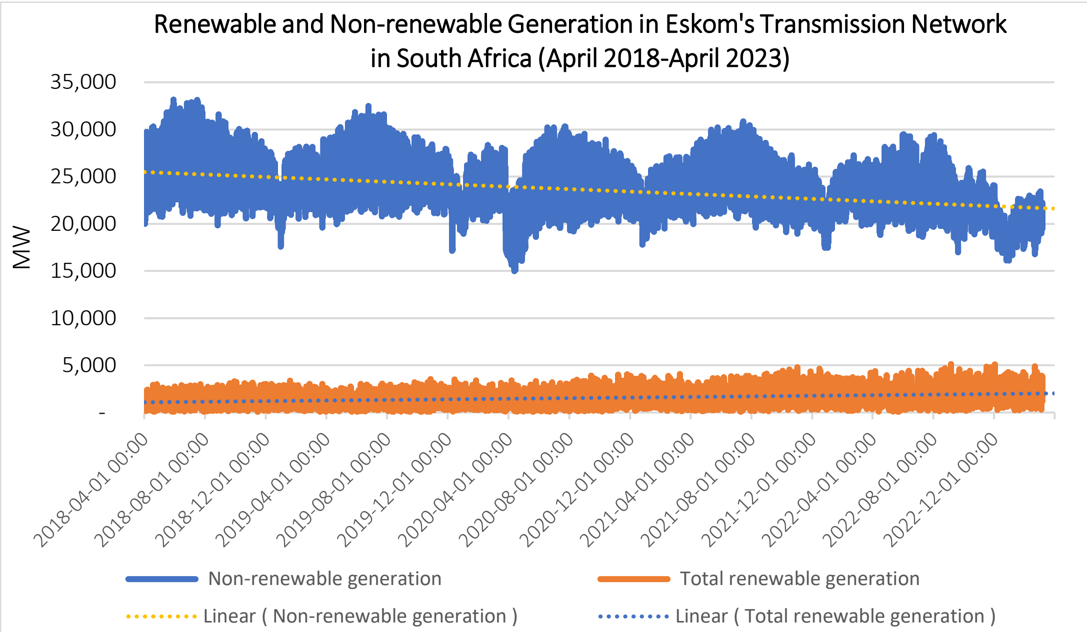
#1	Establishment of crisis as urgent issue
#2	Governmental priority-setting in policy work
#3	Renewables' potential to mitigate crisis
#4	Creation of RMIPPPP to alleviate electricity crisis
#5	Crisis as driver for all energy sources
#6	Crisis as driver for increasing energy supply diversity
#7	Crisis as driver for increased renewable generation/procurement
#8	Environmental considerations as driver for more renewables
#9	Divergence between government's announced plans and actions

First, government documents stress the urgency and negative impacts of the electricity crisis on South Africa *(#1)*, which justifies swift actions to mitigate loadshedding with different strategies. The recently established role of the electricity minister (Reed, 2023) shows that the national government has made ending loadshedding a priority *(#2)*, at least narratively. Since much of the national crisis plans revolve around renewables and IPPs, policymakers use the crisis to push green energy sources. That is supported by the underlined potential of renewables to mitigate the electricity crisis *(#3)*. If such energy sources help the government end loadshedding, it is politically sensible to increase their generation within the national grid. Considering the dire urgency of procuring additional electricity capacity in South Africa, renewables provide short-term benefits due to them getting on the grid faster than fossil fuels (National Planning Commission, 2022; Tierney & Bird, 2020). Especially when combining green technologies and storage opportunities, renewables are extremely valuable (Mamphogoro, Madushele & Pretorius, 2022), like in the RMIPPPP. This programme was created to procure generation capacity from different technologies to fill the electricity supply gap that led to loadshedding *(#4)*.

Furthermore, the analysis suggests that most government communication argues for strengthening all energy sources, namely fossil and RE, in light of the crisis *(#5)*. Considering the far-reaching impacts of loadshedding, it makes sense to employ all possible sources that mitigate the situation, hence making energy security a crucial driver for South Africa's electricity sector developments. In turn, loadshedding drives renewables as a part of the national electricity mix. Thus, the increasing use of green energies is mainly due to the need to diversify *(#6)*. As the diversification of the power sector is one of the best mitigation strategies for energy crises (Ndlovu & Inglesi-Lotz, 2019), renewables become a means to an end to conclude loadshedding.

Figure 8 depicts the electricity shares in South Africa's national grid split between renewables and fossil sources in the past five years. It indicates that renewables alone cannot mitigate the electricity crisis with their comparatively small output, especially if South Africa's economic growth recovers (Eskom, 2022c). Still, they are contributing a consistently growing share, providing relief for South Africa's strained electricity grid. As explained above, the government is pushing for increased generation of all energy sources. Yet, while fossil generation decreased over the past years, renewables have grown. This suggests that the measures taken to end loadshedding are more successful in driving renewables than fossil sources. In the context of ageing expensive coal plants (du Venage, 2020) as well as the longer construction times of fossil generation capacity, renewables thus emerge as a solution for energy supply challenges *(#7)*.

Figure 8: Generation in Eskom's Electricity Grid from April 2018 to April 2023

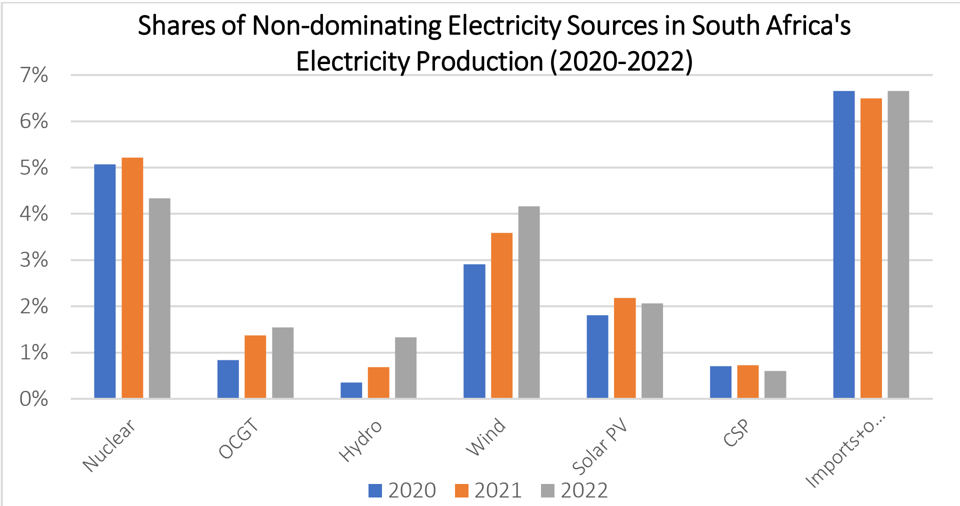


Note: Non-renewable includes coal, nuclear, gas, OCGT, hydro & pumped water generation; renewable includes wind, solar, CSP & biofuels
Data obtained from Eskom, 2023b

Nevertheless, questions remain about whether environmental concerns drive renewables more than loadshedding. This does not seem to apply to South Africa *(#8)* since environmental considerations are solely mentioned in the context of the energy trilemma. This concept highlights the balancing act of sustainable energy systems that must encompass economic, environmental and supply security dimensions (Mawhood & Sutherland, 2023). Since energy security concerns are often mentioned by themselves, climate change mitigation does not bear the same weight in South Africa, making supply security strategies the more impactful driving factor in the electricity crisis (Hanto et al., 2022b, p.168). Interestingly, this result only stands out in the analysis of relatively recent documents since environmental concerns were deemed more essential before loadshedding began, highlighting the rising importance of energy security.

Lastly, although the government's mitigation plans sound promising and entail a considerable increase in renewable capacity compared to before the crisis, there is a growing divergence between announced plans and resulting action *(#9)*. Thus, while the narrative change and political priority-setting regarding green technologies result from worsening loadshedding, the electricity crisis is not pushing generation as much as it seems. That is not just due to inaction but also other factors that are explained in the coming sections. The same becomes evident in *Figure 9*, which depicts the electricity production shares of non-dominating sources in South Africa's electricity grid. I exclude coal since its 80% national production share overshadows the other sources, making their contribution almost negligible. Within these supplementary energy sources, renewables exhibit the largest electricity generation. So, while renewables are driven by the crisis and increasingly impactful, they will most likely stay solely supplementary to fossil sources and especially coal.

Figure 9: Electricity Production Shares of Supplementary Energy Sources in South Africa from 2020 to 2022



Data obtained from Calitz & Wright, 2019, p.18, 2020, p.18, 2021, p.207; Pierce & Ferreira, 2022, pp.9–10, 179; Pierce & Le Roux, 2023, pp.8–12, 110–118

5.3. Factors Affecting Renewables' Progress

To answer the sub-research question of which factors affect renewables' developments in South Africa, I summarise my qualitative analysis results in the second summary table in *Appendix C*. During the analysis, twelve themes emerged that are presented in *Table 4*. These encompass both barriers and drivers of renewable developments in South Africa, ranging from technical to political-economic aspects.

Table 4: Overview of Qualitative Analysis Results for RQ2 *(Source: Appendix C)*

#10	Sustained interest by private sector in IPP programmes for renewables
#11	Price decreases as driving factor of renewables
#12	Protests and public pressure on Eskom and government
#13	Grid constraints as technical hindrance
#14	Volatility of renewable generation
#15	Delays in IPP processes
#16	Bureaucratic process of IPP procurement
#17	Dependence of IPP procurement on Eskom's cooperation
#18	Eskom's monopoly position
#19	Problems at Eskom
#20	Path dependence of coal-based economy
#21	Recent political scepticism towards renewables for crisis mitigation and consequences

5.3.1. Supporting Factors for Renewables in South Africa

The complexity of the IPP processes, which was brought up in *Section 2.3*, does not seem to impact the programmes' success, since the renewables' bid windows have generated sustained interest by the private sector and foreign investors *(#10)*. Consequently, the competitive design of the IPP programmes fulfils its purpose, leading to extensive tariff decreases for newly procured renewable electricity *(#11)*. That is another driver of green technologies considering the importance of affordable energy (Hanto et al., 2022a, p.306). Particularly the REIPPPP price reductions from an average of R3.12/kWh in BW1 (IPP Office, 2021, p.4) to an average of R0.49/kWh in BW6 (IPP Office, 2023a, p.13) underline that. In contrast, Eskom's rising prices for mainly coal-fuelled electricity (Labuschagne, 2020) and worsening loadshedding impacts have led to growing pressure on Eskom and the South African government from the public *(#12)*. As protests urge policymakers in the country to act, they indirectly foster the deployment of renewables which are often part of mitigation strategies like the prior section established

5.3.2. Hindrances for Renewables in South Africa

Nonetheless, while the crisis narratively pushes South Africa's renewable energy forward, several hindrances prevent further advancements of green technologies. One such barrier is grid constraints that limit how much additional capacity is feasible for the existing infrastructure *(#13)*. According to Terblanche and Radmore (2023, p.35), exhausted grid capacity led to the IPP Office only being able to procure 1,000 MW out of the announced 5,200 MW in REIPPPP BW6. Especially renewable energy challenges the grid more than fossil sources due to the high volatility of such generation *(#14)*, further complicating the situation.

Apart from technical obstacles, IPP processes have also faced delays *(#15)* since recent procurement rounds took significantly longer than planned (Todd & McCauley, 2021, p.3). Often, this results from complicated bureaucratic processes and high economic development criteria *(#16)*. Although I have shown that this does not deter IPPs from bidding for projects, it prolongs the process of getting urgently needed capacity on the grid. Furthermore, delays are often related to the dependence of said processes on Eskom's cooperation *(#17)*. IPP projects can only start construction after finalising paperwork that relies on Eskom's signature, which has been outright refused by the utility in the past (Baker, 2017a, p.105).

Eskom's central role in the IPP processes is further impeded by the utility's monopoly position *(#18)*, which IPPs as new power providers threaten (Morris & Martin, 2015). Additionally, the company has suffered from issues like mismanagement and corruption for years *(#19)*. That not only affects Eskom's ability to cooperate in procurement processes but also hinders the mitigation of technical grid constraints, thus sometimes preventing the plans of South Africa's government for renewables to come into practice.

The high reliance of South Africa's electricity grid on Eskom and fossil fuels was not created in a vacuum but follows the path dependence of last century's coal-based economy *(#20)*. In a world where global trends point at low-carbon transitions (IEA, 2022a), South Africa has become a country where it seems almost impossible to move away from coal as the primary energy source (Matikinca, 2023). Although it would be unreasonable to overthrow the entire electricity mix and remove the dominant electricity source amid an energy crisis, recent political scepticism towards renewables even threatens green technologies as a supplementary source *(#21)*. After all, regularly switching up far-reaching policy strategies, like the newly established electricity minister has done (Cele, 2023), jeopardises the success of mitigation strategies (Nyathi, 2023b), which include renewable developments. That is particularly true for energy policy which usually takes a few years to generate meaningful effects due to the time lag between procuring energy and getting it on the grid (Hypertext, 2022; IEA, 2022b).

6. Discussion of Results

This section discusses previously presented findings and puts them into context with established literature and the energy security dimensions in *Table 5*.

Table 5: Energy Security Dimensions within South Africa's Electricity Crisis

A)	Short-term availability of undisrupted electricity
B)	Affordability of electricity
C)	Acceptability of energy regime
D)	Long-run sustainability of the electricity sector
E)	Infrastructural foundation to support stable electricity supply

6.1. South African Electricity Crisis as Driver for Renewables

As the analysis presents, renewable IPP capacity increased significantly during the electricity crisis, thus indicating that energy security drives the deployment of green technologies in South Africa. That is stressed by the fact that only renewable sources increased their contribution to the electricity grid while fossil energies decreased their output.

Among the established energy security dimensions, an undisrupted electricity supply is most crucial in the ongoing loadshedding crisis. Empirical findings suggest that such energy security concerns matter significantly more than environmental considerations or community benefits in South Africa (Kamanzi, 2021, p.28; Morris & Martin, 2015, p.6). Therefore, this thesis' previous findings of energy insecurity affecting renewables are confirmed, also supporting prior literature on the topic (Ibrahiem & Hanafy, 2021; IRENA, 2020; World Bank Group, 2022). Moreover, Walwyn and Brent (2015, p.391) mention the lacking economic incentive to push renewable generation due to the considerably higher prices of REIPPPP electricity compared to Eskom's coal-fuelled power at the time of the REIPPPP's implementation. Consequently, South Africa's government seems to have had more intrinsic reasons for establishing the green IPP programmes, namely to secure another energy source's electricity supply.

Nevertheless, combining energy security and sustainability-related dimensions increases the effectiveness of both, as Lucas, Francés and González (2016) explain. South Africa aims for such synergy through the energy trilemma, balancing sustainability, affordability and security, as the analysis shows. Yet, their focus is increasingly shifting away from environmental concerns, as recent statements by South Africa's electricity minister indicate (Nyathi, 2023b). Although this scepticism of renewables' intrinsic value can threaten the electricity sector's long-term green transition, this does not bear short-run implications. After all, it is inevitable to increase South Africa's generation capacity as swiftly as possible (Steyn et al., 2022). Hence, loadshedding drives all energy sources, which the analysis and literature review argue as well.

While Lawrence (2020, p.102) stresses the importance of diversification, he explains that fossil-based IPP programmes barely contribute to national electricity generation due to their exorbitant costs and slow construction times. These downsides are probably the reason for the low production outputs of non-renewable IPPs (Gxasheka et al., 2023), which strengthens the role of renewables in South Africa's crisis and can further secure their political support. The faster construction and procurement times of renewables compared to fossil plants (Eberhard & Naude, 2016, p.2), underline the benefits of green technologies as a solution to loadshedding.

Nevertheless, renewable sources carry downfalls that can negatively impact energy security. If green energies generated negative effects, the theory of energy insecurity driving renewables could be partly disproven. Augutis et al. (2014) argue that once green technologies' shares in energy mixes reach 60%, adverse effects outweigh the benefits. They explain this with the negative outcomes of lacking diversity, either of producers or energy sources, in power sectors. Yet, South Africa's electricity market currently faces the dominance of Eskom as a producer and coal as a source, so increasing the share of renewables would likely not generate worse outcomes. Moreover, it is almost impossible for non-fossil energy in South Africa to reach such high production shares anytime soon, considering the progress' sluggishness and notion of renewables as solely supplementary sources.

This supplementary nature applies to the REIPPPP and RMIPPPP too (Lawrence, 2020b). According to Ndlovu and Inglesi-Lotz (2019, p.25), South Africa's government shows no interest in becoming a low-carbon economy but views renewables as a means to solve energy challenges, similar to the analysis' findings. Jabeen, Ahmad and Zhang (2023) also argue that the public viewing renewables solely as a solution to loadshedding but not long-term alternative to coal is a significant social bottleneck. Hence, while the crisis is pushing green technologies, it is only doing so up until a glass ceiling, which the analysis supports.

Likewise, should renewables fail to mitigate the electricity crisis, as recent reports suggest (Eskom, 2022c, p.2), or worsen the situation due to the mentioned volatility issues, loadshedding may end up pushing renewables even further away. That would follow Bassetti's (2022) line of argumentation of energy supply crises creating the opposite effect for green technologies as expected. However, considering that South Africa's crisis is based on Eskom's inability to procure sufficient energy, the maximum diversification of electricity sources and producers is inevitable. Thus, renewables seem unavoidable, especially if the country overcomes unemployment and Covid-recovery challenges (National Treasury Republic of South Africa, 2022) and experiences economic growth again.

As the analysis presents, REIPPPP plants have contributed around 90 TWh of electricity since being connected to the grid in 2013. Among the supplementary power sources in South Africa, this is a significant contribution. Consequently, renewables mitigate loadshedding at least slightly. That can create a positive feedback mechanism, where the non-fossil sources' beneficial effects drive further increases in their capacity. As shown in the literature review, non-fossil sources could counteract most loadshedding by generating sufficient power during peak demand hours (Roff et al., 2022). Considering the positive effect of REIPPPP generation on reducing high-demand hours (Pierce & Le Roux, 2023, p.105), that is the case, albeit the current renewable capacity is not yet sufficient to mitigate most of loadshedding.

Another component of energy security during South Africa's electricity crisis is the affordability of power. Supporting the previous analysis, Eberhard and Naude (2016) as well as IRENA (2020, p.54) argue that the IPP programmes' competitive design succeeded in making renewables amongst the cheapest electricity sources in South Africa, which are at least "cost-competitive" (Baker, 2017a, p.104) with Eskom's coal-based power. Findings from Akinbami, Oke and Bodunrin (2021) as well as Doorga, Hall and Eyre (2022) support this notion too.

A second facet of renewables' affordability is the availability of international funding to strengthen low-carbon energy sources, which South Africa has obtained through the Just-Energy-Transition-Programme (The Presidency Republic of South Africa, 2022b). Yet, the recently emerging scepticism towards renewables put such funding at risk (Nyathi, 2023b). Nevertheless, decreasing costs of solar PV and onshore wind (International Trade Administration, 2021) suggest that expenditures are a driver of renewables, particularly since recent REIPPPP bid windows solely procured these sources. As the literature review establishes, South Africa is endowed with an abundance of easily-accessible and cheap wind and sun, presenting a viable alternative to Eskom's expensive coal-fuelled electricity.

Overall, renewable energy is fostered by short-run energy disruptions and high affordability. Still, long-run security and sustainability require reforming the struggling electricity sector (World Bank Group, 2022), if the goal is not short-term loadshedding mitigation but eradicating it for good. In light of the issues surrounding Eskom's fleet (BizNews, 2023), fixing the crisis' symptoms is not enough. The literature review shows that Nepal only ended loadshedding after overturning its power sector. Yet, South Africa has not attempted to fix the problem's root, namely the structure of the electricity sector. If the government wants a long-term sustainable energy sector, including non-finite renewable resources (Doorga, Hall & Eyre, 2022, p.17) seems inevitable. Therefore, there is much potential for future advances in renewable capacity.

6.2. Barriers for Renewables' Development in South Africa

As established in the analysis, the implementation of intended measures responding to loadshedding has progressed too slowly. An EYGM report (2021, p.13) supports this by stressing that the narrative of renewables as a solution to loadshedding has not yet unlocked all momentum. Academic literature mainly explains this lacking progress with high transaction costs for IPP bidders due to the economic benefit requirements (Eberhard, 2013, p.6; Todd & McCauley, 2021, p.5). Yet, the previous analysis does not support this argument based on the sustained private sector's interest in the REIPPPP. If anything, it seems like the crisis is attracting more bidders and consequently fostering renewables, since the government is backing the REIPPPP and RMIPPPP (Eberhard, 2013, p.5) in light of the worsening electricity crisis.

Instead, the IPP programmes suffered from being initiated too late to mitigate loadshedding and from delays in procurement processes as the analysis outlined. Such delays have often been addressed in the literature, with Steyn et al. (2022) claiming that sufficient electricity capacity could be connected to the grid already if not for political stalling. Several authors attribute these delays to Eskom's central role in the IPP processes since the utility prevents IPP's influence wherever possible to protect its monopoly (Baker, 2017a, p.103; Kamanzi, 2021, p.21; Todd & McCauley, 2021). Morris and Martin (2015, p.67) even call the existence of IPPs as "the biggest threat to ESKOM", highlighting the utility's detrimental effects on renewable deployment in South Africa, which the prior analysis also mentions.

Eskom's efforts to hinder renewable IPP advancements connect to the strong MEC in the country, which the literature review considers the main political-economic barrier to green technologies in South Africa (Hanto et al., 2022a). Some authors even argue that the utility took advantage of the electricity crisis by securing its monopoly because no actor would overthrow Eskom's standing in fear of exacerbating the ongoing crisis (Morris & Martin, 2015). Heinemann (2019) confirms this by connecting the dominance to South Africa's historical coal abundance, which created the dependence during British colonisation (van Ryneveld & Islar, 2023). This path dependence normalised the dominance of coal and constitutes an obstacle for renewables, as prior analysis suggests.

Although many countries have overcome such path dependence and smashed their coal sectors, South Africa is headed a different course due to the perplexing interrelatedness of MEC and governmental interests. Since the national government is the utility's sole shareholder (Eskom, 2021), it exercises influence over Eskom. Yet, this also means that both actors' interests are structurally intertwined, making political developments burdensome. Kapilima (2020, p.226) highlights the political influence which stems from dominating a country's central resources, like electricity. Following this notion, it makes sense that Eskom and the MEC exercise such power in South Africa's policymaking and often stand in the way of much-needed renewable deployment. Moreover, Cerna (2013, p.4) explains that institutions' stickiness leads to "actors protect[ing] the existing model, even if it's suboptimal". Such institutional path dependence hinders changes in South Africa's electricity sector, although Eskom and the coal lobby are slowly losing their tight grip on political power due to their inability to mitigate loadshedding.

The reliance of electricity sector developments on Eskom becomes more problematic with all the issues the utility faced in the past. The last sections highlight these problems, ranging from corruption to mismanagement, which led to the downgrading of Eskom's investment rating (Baker, 2017a, p.102). Considering how interrelated the state utility and government are, this also affects South Africa's ratings, therefore jeopardising foreign investments (Baker, 2017a). These investments are crucial for the REIPPPP and RMIPPPP's success, as *3.3* established. Yet, as the sustained interest in IPP programmes in the analysis shows, the willingness of foreign developers to invest in South African renewables has not been impacted so far.

Nonetheless, Eskom's lacking financial stability affects its ability to maintain and expand the grid, as pointed out in the analysis and by Roff et al. (2022). Although Jabeen, Ahmad and Zhang (2023, p.22660) suggest that technical bottlenecks are least important in South Africa's context, my analysis counteracts this. After all, BW6 procurement was scaled down due to grid constraints since national capacity is already exhausted for some provinces. The majority of literature on the topic (Baker, 2017a; Eberhard, 2013, p.6; EYGM, 2021, p.12; Morris & Martin, 2015) supports this point of view. Likewise, the International Trade Administration (2021) provides estimates that around 8,000 km of transmission infrastructure needs to be built to connect large amounts of renewables to the grid, indicating that this technical factor is a large hindrance to green technologies' progress in South Africa.

Overall, Eskom's inability to mitigate the electricity crisis and underlying supply issues resulted in crumbling public support for the utility (Morris & Martin, 2015). Considering the importance of energy regimes' acceptance for energy security, this is problematic. Although Kamanzi (2021, p.22) argues that environmental concerns pressure South Africa's government towards a low-carbon transition, increasing loadshedding protests (AfricaNews, 2023; Steenkamp, 2023) suggest that the public considers the electricity crisis more urgent. Since the government's actions regarding IPPs have also been heavily criticised by individuals resisting privatization (Gqubule, 2022), there seems to be no public consensus about preferred power sector policies. Therefore, no opinion has managed to gain sufficient salience and coherence that would allow it to influence policymakers, according to Neimanns' (2021) analysis of policymaking. Consequently, the energy regime's acceptability is overall ambivalent in the relationship between South Africa's electricity crisis and renewables.

Following Eskom's fleeting trust as a reliable energy supplier, people have been calling for the government to proceed with its unbundling. As Bassetti (2022) argues, energy crises can open the gates for long-term change in power sectors, highlighting the current potential for South Africa's electricity market. Although the government planned to finish unbundling Eskom by late 2022 (Ayamolowo, Manditereza & Kusakana, 2022, p.1212), no efforts were made until recently. This spring, the responsible authorities are supposed to kickstart the unbundling as most paperwork has been finalised (Nyathi, 2023a). Doing so, "would create a level playing field [for renewable energy]" (Morris & Martin, 2015, p.68). As a result, unbundling Eskom bears the potential to end loadshedding and opens the way for renewables in South Africa as IPPs would no longer be disadvantaged compared to the dominating state utility.

Still, the convoluted circumstances of Eskom and the national electricity sector remain somewhat incomprehensible. *Section 2.3* outlines the lacking regulatory capacity of South Africa's government, which initially created the crisis and now hinders its mitigation. Despite knowing what should be done regarding renewables, lobby interests block urgently-needed change. Especially the government's inaction is difficult to comprehend, considering the country's extreme unemployment and inequality. A recent scandal surrounding former Eskom CEO de Ruyter depicts how chaotic the developments in South Africa's electricity sector are. While he accuses the government of stealing from the utility (Cotterill, 2023), policymakers accuse him of purposefully fostering loadshedding (Lo, 2023). Moreover, there are rumours of the national government deliberately destroying Eskom to give way to the private sector (Seepe, 2023). While it is outside this thesis' scope to establish any objective findings regarding that, this shows that the electricity sector issues are intertwined with political, corporate and lobby interests that have created puzzling circumstances in South Africa's policymaking.

7. Conclusion

This thesis has researched the relationship between South Africa's electricity crisis and procurement of renewable energy. Apart from testing whether the framework of energy security as a significant driver for renewables applies to this case, the second aim was to find potential hindrances that affect this relationship. The research was conducted through a mixed-methods case study, which enabled studying a diverse set of sources from different perspectives, thus helping to mitigate the study's limitations.

Overall, the findings show that South Africa's electricity crisis is a relevant driver of renewables within the national IPP programmes. After all, the discussion presents that low-carbon energy sources are fostered by short-term supply security, renewables' comparative affordability and their contribution to the long-run sustainability of the energy sector. Acceptability of the current energy regime, on the other hand, does not have a clear impact on South Africa's developments. Likewise, the electricity sector's infrastructure is not pushing renewables within the loadshedding crisis, considering how restrictive grid constraints are for future IPP procurement.

Nonetheless, the role of renewables has risen significantly through the electricity crisis. That is mainly due to the government pushing all energy sources, rather than actively supporting a low-carbon electricity transition. Since renewable generation has grown during loadshedding, its potential to expand further as the crisis worsens is highlighted. Yet, South African electricity policies aim for coal to stay the dominant electricity source in the future, leaving renewables a supplementary force in the power sector. Consequently, although green energies are momentarily benefitting from the coal-fuelled electricity crisis, it is uncertain whether renewables could continue their success in South Africa if loadshedding ended.

Apart from technical constraints, this thesis identifies other barriers to renewables in South Africa's loadshedding crisis, which relate to the reliance on the failing state utility Eskom. This not only resulted in procurement and maintenance delays but also created the crisis in the first place. Considering the far-reaching impact of the country's Mineral-Energy-Complex and its intertwined incomprehensible relationship with national policymakers, political bottlenecks complicate advancements of renewable energy in South Africa. Although unbundling Eskom bears great potential to mitigate this circumstance, this process is slow as well.

Political delays and technical grid constraints make meaningful progress in mitigating loadshedding and advancing renewable energy tedious. Thus, pathways for green technologies are so limited that the factors that initially led to South Africa's electricity crisis, hence driving renewables, now hinder their further expansion. Still, despite these hindrances, non-fossil generation will likely rise in the coming years with expected worsening loadshedding. In the past, increasing electricity cuts resulted in growing capacity within three years and the same can be anticipated in the future as well.

Since the REIPPPP and RMIPPPP have limited room to showcase their full potential due to the supplementary nature assigned to them, their long-run position in South Africa's power sector is in jeopardy. After all, the national government is mainly interested in ending the symptom of loadshedding rather than eradicating energy insecurity. That shows the deeply-misfunctioning power sector because continuously relying on a policy that has failed in the past is unlikely to suddenly generate improvements. Therefore, renewable deployment can only be fostered so far, even by an impactful energy crisis, when placed on top of a crumbling energy sector.

These findings contribute to the existing literature on energy security frameworks as drivers for renewables. Prior empirical reviews of the impact of energy security usually employ broader concepts instead of focusing on a specific dimension of supply security. By centring this case study on one crisis, I showcase the possible applicability of the framework to a larger variety of cases. Moreover, these findings can be utilised by South African policymakers to understand which barriers are hindering meaningful progress to end loadshedding. Such knowledge is also useful for civil society actors for pressuring stakeholders with coal-favouring interests by identifying how they stall urgently needed progress. Lastly, this thesis opens future research avenues, particularly regarding the convoluted political struggles in South Africa's electricity sector. These are highly impactful for ongoing and coming developments and require detailed analysis. After all, the brief insight in this study only outlines the situation's perplexity when attempting to understand the electricity sector dynamics.

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Appendix A: REIPPPP and RMIPPPP Databases

REIPPPP Project Database

Data obtained from DMRE, 2022a; EDF Renewables, 2023; Hako, 2022; IPP Office, 2023b; IPP Renewables, 2023

BW	Name	Technology	Capacity (MW)	Province	Project Status
1	Aries Solar Energy Facility	Photovoltaic Crystalline Fixed	9.65	Northern Cape	Operational
1	Cookhouse Wind Farm	Onshore Wind	135.8	Eastern Cape	Operational
1	Dassieklip Wind Energy Facility	Onshore Wind	27	Western Cape	Operational
1	De Aar Solar Power	Photovoltaic Crystalline Fixed	45.6	Northern Cape	Operational
1	Dorper Wind Farm	Onshore Wind	97.53	Eastern Cape	Operational
1	Greefspan PV Power Plant	Photovoltaic Crystalline- Single Axis	9.9	Northern Cape	Operational
1	Herbert PV Power Plant	Photovoltaic Crystalline- Single Axis	19.9	Northern Cape	Operational
1	Jeffreys Bay Wind Farm	Onshore Wind	135.11	Eastern Cape	Operational
1	Kalkbult	Photovoltaic Crystalline Fixed	72.4	Northern Cape	Operational
1	Kaxu Solar One	Concentrated Solar Power with storage (min 3h/daily)	100	Northern Cape	Operational
1	Khi Solar One	Concentrated Solar Power with storage (min 3h/daily)	50	Northern Cape	Operational
1	Konkoonsies Solar Energy Facility	Photovoltaic Crystalline Fixed	9.65	Northern Cape	Operational
1	Kouga Wind Farm	Onshore Wind	77.7	Eastern Cape	Operational
1	Lesedi Power Company	Photovoltaic Crystalline Fixed	64	Northern Cape	Operational
1	Letsatsi Power Company	Photovoltaic Crystalline Fixed	64	Free State	Operational
1	Metrowind Van Stadens Wind Farm	Onshore Wind	27	Eastern Cape	Operational
1	Mulilo Renewable Energy Solar PV De Aar	Photovoltaic Crystalline Fixed	10	Northern Cape	Operational
1	Mulilo Renewable Energy Solar PV Prieska	Photovoltaic Crystalline Fixed	19.12	Northern Cape	Operational
1	Nobelsfontein Phase 1	Onshore Wind	73.8	Northern Cape	Operational
1	REISA	Photovoltaic Crystalline- Single Axis	75	Northern Cape	Operational
1	RustMo1 Solar Farm	Photovoltaic Crystalline Fixed	6.93	North West	Operational
1	SDroogfontein Solar Power	Photovoltaic Crystalline Fixed	45.4	Northern Cape	Operational
1	Slimsun Swartland Solar Park	Photovoltaic Crystalline Fixed	5	Western Cape	Operational
1	Solar Capital De Aar	Photovoltaic Thin Film Fixed	75	Northern Cape	Operational
1	Soutpan Solar Park	Photovoltaic Crystalline- Single Axis	27.94	Limpopo	Operational
1	Touwsrivier Project	Photovoltaic Crystalline- Dual Axis	36	Western Cape	Operational
1	Umoya Energy Wind Farm	Onshore Wind	65.4	Western Cape	Operational
1	Witkop Solar Park	Photovoltaic Crystalline- Single Axis	29.68	Limpopo	Operational
2	Amakhala Emoyeni	Onshore Wind	131.05	Eastern Cape	Operational
2	Aurora Wind Power	Onshore Wind	90.82	Western Cape	Operational
2	Aurora-Rietvlei Solar Power	Photovoltaic Crystalline Fixed	8.9	Western Cape	Operational
2	Bokpoort CSP project	Concentrated Solar Power with storage (min 3h/daily)	50	Northern Cape	Operational
2	Boshoff Solar Park	Photovoltaic Crystalline- Single Axis	57	Free State	Operational
2	Chaba Wind Farm	Onshore Wind	21	Eastern Cape	Operational
2	Dreunberg	Photovoltaic Crystalline- Single Axis	69.6	Eastern Cape	Operational
2	Gouda Wind Project	Onshore Wind	135.5	Western Cape	Operational
2	Grassridge Wind Farm	Onshore Wind	59.8	Eastern Cape	Operational
2	Jasper Power Company	Photovoltaic Crystalline Fixed	75	Northern Cape	Operational
2	Linde	Photovoltaic Crystalline- Single Axis	36.8	Northern Cape	Operational
2	Neusberg Hydro Electrical Project	Small Hydro	10	Northern Cape	Operational
2	Sishen Solar Facility	Photovoltaic Crystalline- Single Axis	74	Northern Cape	Operational
2	Solar Capital De Aar 3	Photovoltaic Thin Film Fixed	75	Northern Cape	Operational
2	Stortemelk Hydro	Small Hydro	4.22	Free State	Operational
2	Tsitsikamma Community Wind Farm	Onshore Wind	93.68	Eastern Cape	Operational
2	Upington Airport	Photovoltaic Thin Film Fixed	8.9	Northern Cape	Operational
2	Vredendal Solar Park	Photovoltaic Crystalline Fixed	8.8	Western Cape	Operational
2	Waainek Wind Farm	Onshore Wind	23.28	Eastern Cape	Operational
3	!XiNa Solar One	Concentrated Solar Power with storage (min 3h/daily)	100	Northern Cape	Operational
3	Adams Solar PV 2	Photovoltaic Crystalline Fixed	75	Northern Cape	Operational
3	ENERGY Joburg Landfill Gas to Electircity Project	Landfill Gas	7.56	Gauteng	Operational
3	Karoshoek Solar One	Concentrated Solar Power with storage (min 3h/daily)	100	Northern Cape	Operational
3	Khobab Wind Farm	Onshore Wind	137.74	Northern Cape	Operational
3	Loeriesfontein 2 Wind Farm	Onshore Wind	138.23	Northern Cape	Operational
3	Longyuan Mulilo De Aar Maanhaarberg Wind Energy Facility	Onshore Wind	96.48	Northern Cape	Operational
3	Longyuan Mulilo Green Energy De Aar 2 North Wind Energy Facility	Onshore Wind	138.96	Northern Cape	Operational
3	Mkuze	Biomass	16.5	KwaZulu-Natal	No financial close
3	Mulilo Prieska PV	Photovoltaic Crystalline- Single Axis	75	Northern Cape	Operational
3	Mulilo Sonnedix Prieska PV	Photovoltaic Crystalline Fixed	75	Northern Cape	Operational
3	Nojoli Wind Farm	Onshore Wind	86.6	Eastern Cape	Operational

Continuation of REIPPPP Project Database

Data obtained from DMRE, 2022a; EDF Renewables, 2023; Hako, 2022; IPP Office, 2023b; IPP Renewables, 2023

BW	Name	Technology	Capacity (MW)	Province	Project Status
3	Noupoort Wind Farm	Onshore Wind	79.05	Northern Cape	Operational
3	Paleisheuwel	Photovoltaic Crystalline Fixed	75	Western Cape	Operational
3	Pulida Solar Park	Photovoltaic Thin Film Fixed	75	Free State	Operational
3	Red Cap - Gibson Bay	Onshore Wind	108.25	Eastern Cape	Operational
3	Tom Burke Solar Park	Photovoltaic Thin Film Fixed	60	Limpopo	Operational
3.5	Kathu Solar Park	Concentrated Solar Power with storage (min 3h/daily)	100	Northern Cape	Operational
3.5	Redstone Solar Thermal Power Plant	Concentrated Solar Power with storage (min 3h/daily)	100	Northern Cape	Under construction
4	Aggeneys Solar	Photovoltaic Crystalline- Single Axis	40	Northern Cape	Operational
4	Boikanyo Solar	Photovoltaic Crystalline- Single Axis	55	Northern Cape	Operational
4	Bokamoso	Photovoltaic Crystalline- Single Axis	67.9	North West	Operational
4	Copperton Windfarm	Onshore Wind	102	Northern Cape	Operational
4	De Wildt	Photovoltaic Crystalline- Single Axis	50	North West	Operational
4	Dyason's Klip 1	Photovoltaic Crystalline- Single Axis	75	Northern Cape	Operational
4	Dyason's Klip 2	Photovoltaic Crystalline- Single Axis	75	Northern Cape	Operational
4	Excelsior Wind Energy Facility	Onshore Wind	31.9	Western Cape	Operational
4	Garob Wind Farm	Onshore Wind	135.93	Northern Cape	Operational
4	Golden Valley Wind	Onshore Wind	117.72	Eastern Cape	Operational
4	Kangnas Wind Farm	Onshore Wind	136.7	Northern Cape	Operational
4	Konkoonsies II Solar PV Facility	Photovoltaic Crystalline- Single Axis	75	Northern Cape	Operational
4	Kruisvallei Hydro	Small Hydro	3.8	Free State	Operational
4	Matla A Bokone Solar	Photovoltaic Crystalline- Single Axis	75	Northern Cape	Operational
4	Ngodwana Energy	Biomass	25	Mpumalanga	Operational
4	Nxuba Wind Farm	Onshore Wind	138.9	Eastern Cape	Operational
4	Oyster Bay Wind Farm	Onshore Wind	140	Eastern Cape	Operational
4	Perdekraal East Wind Farm	Onshore Wind	107.76	Western Cape	Operational
4	Roggeveld Wind Farm	Onshore Wind	140	Northern Cape	Operational
4	Sirius Solar PV Project One	Photovoltaic Crystalline- Single Axis	75	Northern Cape	Operational
4	Soetwater Wind Farm	Onshore Wind	139.4	Northern Cape	Under construction
4	Solar Capital Orange	Photovoltaic Crystalline- Single Axis	75	Northern Cape	Under construction
4	The Karusa Wind Farm	Onshore Wind	139.8	Northern Cape	Operational
4	Waterloo Solar Park	Photovoltaic Crystalline- Single Axis	75	North West	Operational
4	Wesley-Ciskei	Onshore Wind	32.7	Eastern Cape	Operational
4	Zeerust	Photovoltaic Crystalline- Single Axis	75	North West	Operational
5	Dwarsrug Wind Facility	Onshore Wind	124	Northern Cape	Permitting stage
5	Beaufort West Wind Facility	Onshore Wind	140	Western Cape	Permitting stage
5	Trakas Wind Facility	Onshore Wind	140	Western Cape	Permitting stage
5	Sutherland Wind Facility	Onshore Wind	140	Northern Cape	Permitting stage
5	Rietrug Wind Facility	Onshore Wind	140	Northern Cape	Permitting stage
5	Brandvalley Wind Farm	Onshore Wind	140	Western Cape	PPA signed
5	Rietkloof Wind Farm	Onshore Wind	140	Western Cape	PPA signed
5	Waaihoek Wind Facility	Onshore Wind	140	KwaZulu-Natal	Permitting stage
5	San Kraal WEF	Onshore Wind	140	Northern Cape	Financial close
5	Phezukomoya WEF	Onshore Wind	140	Northern Cape	Financial close
5	Coleskop WEF	Onshore Wind	140	Northern Cape	Financial close
5	Wolf Wind Farm	Onshore Wind	84	Eastern Cape	PPA signed
5	Kentani Solar Facility	Photovoltaic	75	Free State	PPA signed
5	Klipfontein Solar Facility	Photovoltaic	75	Free State	PPA signed
5	Klipfontein 2 Solar Facility	Photovoltaic	75	Free State	PPA signed
5	Leliehoek Solar Facility	Photovoltaic	75	Free State	PPA signed
5	Braklaagte Solar Facility	Photovoltaic	75	Free State	PPA signed
5	Sonoblomo Solar Facility	Photovoltaic	75	Free State	PPA signed
5	Du Plessis Dam Solar PV 1	Photovoltaic	75	Northern Cape	PPA signed
5	Graspan Solar PV Project	Photovoltaic	75	Northern Cape	PPA signed
5	Grootspruit Solar PV Project	Photovoltaic	75	Free State	PPA signed
5	Sannaspos Solar PV Project	Photovoltaic	75	Free State	PPA signed
5	Grootfontein PV 1	Photovoltaic	75	Western Cape	PPA signed
5	Grootfontein PV 2	Photovoltaic	75	Western Cape	PPA signed
5	Grootfontein PV 3	Photovoltaic	75	Western Cape	PPA signed
6	Kutlwano Solar Power Plant	Photovoltaic	150	North West	Preferred bidder
6	Boitumelo Solar Power Plant	Photovoltaic	150	North West	Preferred bidder
6	Virginia Solar Park	Photovoltaic	240	Free State	Preferred bidder
6	Good Hope Solar Park	Photovoltaic	200	Free State	Preferred bidder
6	Doornhoek PV	Photovoltaic	120	North West	Preferred bidder
6	Ngonyama Solar PV	Photovoltaic	140	Free State	Preferred bidder

RMIPPPP Project Database

Data obtained from DMRE, 2021b, 2021c, 2022b

BW	Name	Technology	Capacity (MW)	Province	Project Status
1	Scatec Kenhardt 1	Solar Photovoltaic and battery storage	50	Northern Cape	Financial close
1	Scatec Kenhardt 2	Solar Photovoltaic and battery storage	50	Northern Cape	Finacial close
1	Scatec Kenhardt 3	Solar Photovoltaic and battery storage	50	Northern Cape	Financial close
1	Oya Energy Hybrid Facility	Solar Photovoltaic and battery storage, Diesel, Onshore Wind	128	Western Cape	Preferred bidder
1	Umoyilanga Energy	Solar PV, Battery Storage, LPG, Onshore Wind	75	Eastern/Northern Cape	Preferred bidder
1	ACWA Power Project DAO	Solar PV, Battery Storage, Diesel	150	Northern Cape	Preferred bidder
1	Karpowership SA Coega	Floating Modular Reciprocating Gas Engines	450	Eastern Cape	Preferred bidder
1	Karpowership SA Richards Bay	Floating Modular Reciprocating Gas Engines	450	KZN	Preferred bidder
1	Karpowership SA Saldanha	Floating Modular Reciprocating Gas Engines	320	Western Cape	Preferred bidder
1	Mulilo Total Coega	Solar PV, Reciprocating Gas Engines	197.76	Eastern Cape	Preferred bidder
1	Mulilo Total Hydra Storage	Solar PV, Battery Storage, Diesel	75	Northern Cape	Preferred bidder

Appendix B: Descriptive SPSS Statistics of REIPPPP Database

Overview of Descriptive Statistics for REIPPPP Database variable "Capacity in MW"

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation
Capcity in MW	123	236.20	3.80	240.00	9879.74	80.3231	46.50462
Valid N (listwise)	123						

Frequency Table of "Bid Window"-variable for REIPPPP

Bid Window

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	28	22.8	22.8	22.8
	2.0	19	15.4	15.4	38.2
	3.0	17	13.8	13.8	52.0
	3.5	2	1.6	1.6	53.7
	4.0	26	21.1	21.1	74.8
	5.0	25	20.3	20.3	95.1
	6.0	6	4.9	4.9	100.0
	Total	123	100.0	100.0	

Frequency Table of "Status of Project"-variable for REIPPPP

Status of Project

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Financial close	3	2.4	2.4	2.4
	Operational	88	71.5	71.5	74.0
	Permitting stage	6	4.9	4.9	78.9
	PPA signed	17	13.8	13.8	92.7
	Preferred bidder	6	4.9	4.9	97.6
	Under construction	3	2.4	2.4	100.0
	Total	123	100.0	100.0	

Frequency Table of "Province location"-variable for REIPPPP

Province where Project is located

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Eastern Cape	18	14.6	14.6	14.6
	Free State	16	13.0	13.0	27.6
	Gauteng	1	.8	.8	28.5
	KwaZulu-Natal	2	1.6	1.6	30.1
	Limpopo	3	2.4	2.4	32.5
	Mpumalanga	1	.8	.8	33.3
	North West	8	6.5	6.5	39.8
	Northern Cape	1	.8	.8	40.7
	Northern Cape	55	44.7	44.7	85.4
	Western Cape	18	14.6	14.6	100.0
	Total	123	100.0	100.0	

Frequency Table of "Technology type"-variable for REIPPPP

Type of Technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Biomass	2	1.6	1.6	1.6
	Concentrated Solar Power with storage (min 3 hrs per day)	7	5.7	5.7	7.3
	Landfill Gas	1	.8	.8	8.1
	Onshore Wind	46	37.4	37.4	45.5
	Photovoltaic	64	52.0	52.0	97.6
	Small Hydro	3	2.4	2.4	100.0
	Total	123	100.0	100.0	

Crosstabulation of "Bid Window" and "Technology type" variables for REIPPPP

Bid Window * Type of Technology Crosstabulation

Count

		Type of Technology						
		Biomass	Concentrated Solar Power with storage (min 3 hrs per day)	Landfill Gas	Onshore Wind	Photovoltaic	Small Hydro	Total
Bid Window	1.0	0	2	0	8	18	0	28
	2.0	0	1	0	7	9	2	19
	3.0	1	2	1	7	6	0	17
	3.5	0	2	0	0	0	0	2
	4.0	1	0	0	12	12	1	26
	5.0	0	0	0	12	13	0	25
	6.0	0	0	0	0	6	0	6
Total		2	7	1	46	64	3	123

Appendix C: Summary Table Qualitative Analysis

How has the current electricity crisis in South Africa affected the development of renewable energy within the Independent Power Producer Procurement Programmes?

Themes	**References**
(#1) Establishment of crisis as urgent issue	➢ "Load shedding is the single biggest constraint on South Africa's economic growth" (*The Presidency Republic of South Africa, 2022a, p.2)* ➢ "[…] the most urgent problem facing the economy is inadequate electricity supply. [...] A decade and a half of this binding energy constraint has discouraged investment and weighed on economic growth and job creation" *(National Treasury Republic of South Africa, 2022, p.4)*
(#2) Governmental priority-setting in policy work	➢ "A dedicated National Energy Crisis Committee (NECOM) has been established comprising all government departments and Eskom, led by the Director-General in the Presidency, to implement this action plan." *(The Presidency Republic of South Africa, 2022a, p.2)* ➢ "One of the first steps President Ramaphosa took in 2018 was to revive the renewable energy procurement programme. This enabled 2205 MW from Bid Window 4 to proceed to construction […]." *(The Presidency Republic of South Africa, 2022a, p.3)* ➢ Government aims to "accelerate procurement of new capacity from renewables, gas and battery storage" *(The Presidency Republic of South Africa, 2022a, p.6)* ➢ "Ramokgopa was made electricity minister last month by President Cyril Ramaphosa to deal with load-shedding, which has brought businesses and the economy to their knees." *(Nyathi, 2023b, n.p.)* ➢ "Ramokgopa [the newly appointed electricity minister] 'will remain in office only for as long as it is necessary to resolve the electricity crisis', the president said." *(Reed, 2023, n.p.)*
(#3) RE's potential to mitigate crisis	➢ "A massive rollout of renewable energy offers our best chance of ending load shedding as quickly as possible." *(The Presidency Republic of South Africa, 2022a, p.9)* ➢ "Projects from the risk mitigation procurement programme and Bid Window 5 of the REIPPPP will unlock significant new generation capacity and are ready to proceed once approvals are granted." *(The Presidency Republic of South Africa, 2022a, p.5)* ➢ "Mr Magoro highlighted that the 3 Scatec projects signed on 02 June 2022, are a 'first of its kind' in South Africa, combining Solar PV and Battery technologies to contribute 150MW of dispatchable capacity to the national grid." *(DMRE, 2022b, p.1)* ➢ "Solar PV, wind and CSP with storage present an opportunity to diversify the electricity mix, to produce distributed generation and to provide off-grid electricity. Renewable technologies also present huge potential for the creation of new industries, job creation and localisation across the value chain." *(Mantashe, 2019, p.13)* ➢ "Procure power that can be brought online in the shortest possible time" as part of urgent measures announced by President at State of the Nation Address 2020 (DMRE, 2021a) → "Solar and wind power projects can be built rapidly within two to three years." (*National Planning Commission, 2022)*
(#4) Creation of RMIPPPP to alleviate electricity crisis	➢ "The objective of the RMIPPPP is to fill the current short-term supply gap, alleviate the current electricity supply constraints and reduce the extensive utilisation of diesel-based peaking electrical generators." *(IPP Risk Mitigation, 2023, n.p.)* ➢ "The RMIPPPP has been designed to procure the target of 2 000 MW of new generation capacity to be derived from different types of dispatchable electrical power generation projects." *(IPP Office, 2021, p.47)* ➢ "The first [Ministerial] determination, promulgated on 14 May 2020, calls for the procurement of 2 000 MW from a range of technologies, to fill the short-term capacity gap." *(IPP Office, n.d., n.p.)* ➢ "The RMIPPPP is a direct response to fill 2 000 MW of the supply gap […]." *(DMRE, 2020b, n.p.)* ➢ "The system requirements have been specified by Eskom as the System Operator, specifying that the procured solution should be dispatchable, flexible generation able to operate between 5h00 to 21h30. This complements the daily demand profile and is in line with the load-shedding times that we have been experiencing." *(DMRE, 2020b, n.p.)*

(#5) Crisis as driver for all energy sources	➢ "Additional capacity will be made available in the short term by allowing existing IPPs to sell surplus power to Eskom. This will involve amending contracts with existing IPPs from previous bid windows to enable them to sell additional capacity." *(The Presidency Republic of South Africa, 2022a, p.5)* ➢ "A second [Ministerial] determination, which was promulgated in September, allows for procurement from the following technologies, for the short and medium term: 6,800 MW Solar PV and Wind between 2022 and 2024, 513 MW Energy Storage in 2022, 3,000 MW Gas between 2024 and 2027, 1,500 MW Coal between 2023 and 2027" *(IPP Office, n.d., n.p.)* ➢ "The primary mandate of the IPP Office is to secure electricity from renewable and non-renewable energy sources from the private sector." *(IPP Office, 2021, p.1)* ➢ "Mantashe was addressing Eskom CEO André de Ruyter, emphasising that Eskom should focus solely on energy generation, and not let environmental concerns stop it from having procurement in a range of energy technologies like gas and nuclear" *(Evans, 2022, n.p.)* ➢ "The Department of Mineral Resources and Energy's (DMRE) Independent Power Producers Procurement Programme (IPPPP) was established at the end of 2010 as one of the South African government's urgent interventions to enhance South Africa's electrical power generation capacity." *(IPP Office, 2021, p.1)* ➢ Key constraints and risks: "a) reducing carbon emissions […] f) security of supply" *(Department of Energy, 2011, p.8)*
(#6) Crisis as driver for increasing energy supply diversity	➢ Two first objectives of National Energy Act: "(a) ensure uninterrupted supply of energy to the Republic" and "(b) promote diversity of supply of energy and its sources" *(The Presidency Republic of South Africa, 2008, p.6)* ➢ "The [IPPP] programme is contributing to the security of energy supply and ensuring a diversified energy mix through the procurement of significant additional renewable energy and non-renewable generation capacity from the private sector." *(IPP Office, n.d., n.p.)* ➢ "The introduction of private sector generation offers multiple benefits, for example: […] Contributing to the diversification of energy supply and nature of its production, Improving energy security and modernity […]" *(IPP Office, 2021, p.55)* ➢ "Securing supply through diversity" (*DMRE, 2022c, p.9)* ➢ "The driving force for energy security through diversification of supply in South Africa has remained one of the White Paper On Energy Policy's key goals, since a major portion of the nation's energy expenditure is via dollar-denominated imported fuels that impose a heavy burden on the economy." *(DMRE, 2004, p.10)*
(#7) Crisis as driver for increased RE generation/procurement	➢ "Through the NECOM initiatives, procurement of the IRP 2019 capacity will be accelerated, with Bid Window 6 allocated capacity doubling from the initial 2 600 MW to 5 200 MW." *(Eskom, 2022c, p.25)* ➢ "Nonetheless, renewable resources generally operate from an unlimited resource base and, as such, can increasingly contribute towards a long-term sustainable energy future." *(DMRE, 1998, p.79)* ➢ "The capacity procured through [REIPPPP] Bid Window 6 will be doubled from the current allocation of 2600 MW to 5200 MW" (The Presidency Republic of South Africa, 2022a, p.9) ➢ "A second [Ministerial] determination, which was promulgated in September, allows for procurement from the following technologies, for the short and medium term: 6,800 MW Solar PV and Wind between 2022 and 2024 […]." *(IPP Office, n.d., n.p.)* ➢ "Yelland [energy analyst] said it is also unclear that extending the life of power stations is a cheap and quick solution to current energy challenges. […] He said that extending the life of Camden, Hendrina, and Komati [Eskom coal plants] took many years and cost a lot of money." *(Brederode, 2023, n.p.)*
(#8) Environmental considerations as driver for more RE	➢ REIPPPP was "designed to reduce the country's reliance on fossil fuels, stimulate an indigenous renewable energy industry and contribute to socio-economic development and environmentally sustainable growth." *(IPP Office, n.d., n.p.)* ➢ "South Africa's current electricity development strategy aims to achieve a greater balance between these three aspects [promoting economic development, providing energy security and access, achieving environmental sustainability], focusing on achieving a balanced energy mix to include more renewables, gas and energy storage." *(IPP Office, 2021, p.57)* ➢ "The [RMIPPPP] programme also aims to further government's objectives to decarbonize the energy system by advancing technologies that emit less CO2." *(DMRE, 2020b, n.p.)* ➢ Further objective of National Energy Act: "(h) provide for certain safety, health and environment matters that pertain to energy" *(The Presidency Republic of South Africa, 2008, p.6)* ➢ "However, at the same time South Africa recognises that the emissions of greenhouse gases, such as carbon dioxide, from the use of fossil fuels such as coal and petroleum products has led to increasing concerns worldwide, about global climate change. While South Africa is

	well endowed with renewable energy resources that can be sustainable alternatives to fossil fuels, so far these have remained largely untapped.” *(DMRE, 2004, p.8)* ➢ “As part of South Africa’s energy policy objectives, the electricity supply industry objectives must: […] achieve environmental sustainability in both the short and long-term usage of our natural resources” *(DMRE, 1998, p.42)* ➢ “Nonetheless, renewable resources generally operate from an unlimited resource base and, as such, can increasingly contribute towards a long-term sustainable energy future.” *(DMRE, 1998, p.79)* ➢ “South Africa’s JET IP thus seeks to build the country’s resilience in the face of its physical, social and transition climate risks” (The Presidency Republic of South Africa, 2022b, p.24) ➢ Key constraints and risks: “a) reducing carbon emissions […] f) security of supply” *(Department of Energy, 2011, p.8)*
(#9) Divergence between government’s announced plans and actions	➢ “A further 6800 MW of solar PV and wind power is being procured through Bid Windows 5,6 and 7. This additional generation capacity will connect to the grid from late 2023.” (The Presidency Republic of South Africa, 2022a, p.3) – BW7 not even announced yet ➢ “The capacity procured through Bid Window 6 will be doubled from the current allocation of 2600 MW to 5200 MW” *(The Presidency Republic of South Africa, 2022a, p.9)* – actual BW6 capacity procured only 1000MW *(own REIPPPP database)* ➢ “The [RMIPPPP] Preferred Bidders are required to reach Financial Close by no later than the end of July 2021. Due to the urgency to bring power online, this date is not negotiable. It is for the Preferred Bidders to manage all the risks to reach financial close.” *(DMRE, 2021a)* – only three out of eleven RMIPPPP have yet reached financial close *(own RMIPPPP database)*

Which factors are impacting progress in the development of renewable energy in South Africa?

Themes	References
(#10) Sustained interest by private sector in IPP programmes for renewables	➢ "The [RMIPPPP] Bid Submission closed on 22 December 2020 and attracted a total of 28 bid responses with a potential contracted capacity of approximately Five Thousand One Hundred and Seventeen megawatts (5 117MW). This clearly demonstrates a sustained private sector interest in participating in the South African energy landscape." *(DMRE, 2021a)* ➢ "The Department received 102 bids during bid submission [for BW5] on 16th August 2021, totaling an oversubscribed 9 644 MW." *(DMRE, 2022d)*
(#11) Price decreases as driving factor of RE	➢ "Through the competitive bidding process, the IPPPP effectively leveraged rapid, global technology developments and price trends, buying clean energy at lower and lower rates with every bid cycle, resulting in SA getting the benefit of RE at some of the lowest tariffs in the world" *(IPP Office, 2021, p.4)* ➢ "This could result in a combination of technologies, and the blended price of these combined facilities will be much lower than a single fuel-based power plant." *(DMRE, 2020b, n.p.)*
(#12) Protests and public pressure on Eskom and government	➢ "Civil society organisation Stand Up SA gathered droves of supporters to march to power utility Eskom's Sunninghill headquarters in Sandton, Johanesburg, Thursday to demand an end to load shedding and a pending electricity tariff hike. Their demands echoed those of many South Africans facing an energy crisis." *(AfricaNews, 2023, n.p.)* ➢ "The ongoing power outages across Durban has led to sporadic and violent protests in various communities." *(Rall, 2023, n.p.)* ➢ "Thousands of people took to the streets of Cape Town on Wednesday to protest against load-shedding and the 18.65% electricity tariff increase." *(Steenkamp, 2023, n.p.)*
(#13) Grid constraints as technical hindrance	➢ "[…] country supply areas are limited to about 32.4 GW of new generation capacity" *(Matshidza, Satimburwa & Dlamini, 2022, p.6)*
(#14) Volatility of RE generation	➢ "Storage technologies […] are developments which can address this issue [of renewables' timing of production during low-demand periods], especially in the South African context where over 6 GW of renewable energy has been introduced, yet the power system does not have the requisite storage capacity or flexibility." *(Mantashe, 2019, pp.14–15)* ➢ "'It proves that dispatchable renewables are possible. It's cost-effective. And it's available today,' said Fourie." *(Evans, 2022, n.p.)* ➢ "At low levels of penetration, fluctuating renewable energy will have only marginal impact on the system. However, considering the South African energy generation mix and demand profile, there is a point at which an isolated system would have to adjust system and network operations if not configured to cater for the variability of this energy. Indications from the system operator is that at about 20% of renewable energy in the energy mix, ancillary service requirements will start to increase and this is in line with global trends." *(Mantashe, 2019, pp.50–51)*
(#15) Delays in IPP processes	➢ "Policy and legislative delays in the procurement of new electricity generating capacity under the Risk Mitigation Independent Power Producer Procurement Programme and Bid Window 5 of the Renewable Energy Independent Power Producer Procurement Programme have contributed to the power shortage." *(National Treasury Republic of South Africa, 2022, p.13)* ➢ "One of the first steps President Ramaphosa took in 2018 was to revive the renewable energy procurement programme. This enabled 2205 MW from Bid Window 4 to proceed to construction […]." *(The Presidency Republic of South Africa, 2022a, p.3)* ➢ "The Department of Mineral Resources and Energy (the DMRE) announces the postponement of Bid Submission Date for the REIPPPP Bid Window 6." *(DMRE, 2022e)*

(#16) Bureaucratic process of IPP procurement	➢ To achieve goal of additional generation capacity, "there must be a temporary exemption from local content requirements for construction and commissioning of new generation and storage capacity due to come online in the next 36 months. In parallel, key stakeholders should reach a formal agreement that strikes a balance between short-term importation of components with the need for phasing in upstream industrialization over the medium- to long-term." *(National Planning Commission, 2022)* ➢ "[…] another [way to reduce reliance on Eskom] would be to purchase electricity directly from independent power producers (IPPs). Government policy currently allows IPPs to sell electricity only to Eskom, which is controlled through the issuing of generation licences." (*Department of Economic Development and Tourism, 2019, p.7)*
(#17) Dependence of IPP procurement process on Eskom's cooperation	➢ "The decision was informed by the confirmed timelines from Eskom to issue the Budget Quotas to all Preferred Bidders. The Budget Quotas are required in order to finalize costing and commercial operation timelines" *(DMRE, 2022f)* ➢ "To achieve this, work is underway between the IPP Office, Eskom, Operation Vulindlela and the DTIC to ensure that these projects reach financial close as quickly as possible." *(The Presidency Republic of South Africa, 2022a, p.5)*
(#18) Eskom's monopoly position	➢ "Eskom wants to prove that it can be a key player in scaling up South African renewable energy." *(Whitehouse, 2022, n.p.)* ➢ "[…] there remains the strong possibility that its [an academic report's] recommendations will go ignored by the national government, which seems to remain heavily invested in Eskom as the sector's dominant player and coal as the country's primary energy source." *(Hill-Lewis, 2022, n.p.)*
(#19) Problems at Eskom	➢ "Eskom CEO André de Ruyter has admitted that corruption is still rife at the power utility and that patronage networks still exist. […] De Ruyter said incompetence and neglect by Eskom staff is one of the primary reasons for the recent bout of load-shedding." *(MyBroadband, 2021, n.p.)* ➢ "A capable and effective management team has been established in Eskom and is working hard to turn around the utility and reverse years of decay." *(The Presidency Republic of South Africa, 2022a, p.3)* ➢ "In the long term Eskom will have to be restructured into separate generation and transmission companies [to optimize the electricity sector]" (DMRE, 1998, p.55) ➢ "This comes as the newly elected electricity minister, Kgosientsho Ramokgopa, said unbundling the power utility […] was important only in the long term for purposes of achieving energy security." *(Nyathi, 2023a, n.p.)*
(#20) Path dependence of coal-based economy	➢ REIPPPP a "highly liberalized auction instrument within a path-dependent, fossilized economy" which "creates tensions between the fossil-based production chains and new clean energy regime" *(Müller et al., 2020, p.66)* ➢ "As a result, coal is and is likely to remain, from a financial viewpoint, an attractive source of energy for South Africa." (*DMRE, 2004, p.8)* ➢ "There's a need to move beyond the 'binary' debate between proponents of coal and renewable energy, de Ruyter said. There's no way that South Africa will stop using coal to appease the Global North, he argued." *(Whitehouse, 2022, n.p.)* ➢ "'My biggest problem as a person is the polarisation of the debate among energy technologies,' said Mantashe, saying that the debate made it seem that in order for one technology to expand, another must die." *(Evans, 2022, n.p.)* ➢ "Diversification does introduce a risk in moving from dependence on a historically certain fuel supply, specifically coal in South Africa's case, to different commodities and technologies which are less certain (from a historical perspective)." *(Department of Energy, 2011, p.18)*
(#21) Recent political scepticism towards RE for crisis mitigation and consequences	➢ "On Thursday, Ramokgopa announced that he plans to extend the life of Eskom's power stations that are reaching their end of lives by another 20 years, which will cost more than R400 billion. But this would be contingent on whether the cabinet gave him the go-ahead." *(Nyathi, 2023b, n.p.)* ➢ "'The NEC supports the approach that as we prioritize load shedding we will need to re-visit our decommissioning schedule to balance energy security and our climate commitments,' President Cyril Ramaphosa said in his closing address to the ANC's National Executive Committee. […]The strategy would result in the increased use of fossil fuels to mitigate electricity shortages in the country." *(Cele, 2023, n.p.)* ➢ "Speaking at a special cabinet meeting on Wednesday, electricity minister Kgosientsho Ramokgopa reportedly said extending the life of the Eskom coal-fired generation fleet would be crucial to ending load-shedding." *(Brederode, 2023, n.p.)*

	➢ "Chris Yelland, energy analyst and MD of EE Business Intelligence, said extending the life of Eskom's coal-fired power stations could unwind the $8.5 billion (R154 billion) of funding made available to South Africa for its 'Just Energy Transition'." *(Brederode, 2023, n.p.)* ➢ "Yelland [energy analyst] said that he thinks there has been a sudden re-think of these policies as an 'act of desperation.' Many different policies for electricity have been made as the energy crisis has been drawn out over many years and has prompted a wide array of policy responses. Backing out of existing energy policy without properly considering the consequences is unwise, he [Yelland] said." *(Brederode, 2023, n.p.)*