

**An energy mix policy to address the
wicked problem of energy insecurity
in South Africa**

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**A research article submitted to the Faculty of Commerce, Law and
Management, University of the Witwatersrand, in partial fulfilment of the
requirements for the degree of Master of Business Administration**

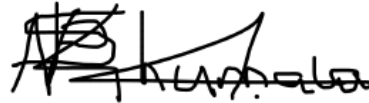
Johannesburg, 2023

Protocol number: WWBS/BA853766/655

DECLARATION

I, Nduduzo Khumalo, declare that this research article is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Nduduzo Siyabonga Percivel Khumalo

A handwritten signature in black ink, appearing to read 'Nduduzo Khumalo', with a stylized, overlapping initial 'N'.

Signed at Johannesburg South

On the 31st day of May 2023

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude and thanks to my supervisor, Senior Lecturer, at Wits – School of Economics and Business Sciences, Dr. Lumkile P. Mondi, for his support and guidance with this study.

Special thanks are due to Prof. Bhekisipho Twala, and my friends at work, MBA Cohort Saturday B, for support and great ideas that made a contribution to this project.

Finally, I would like to thank my family, for sustained support and encouragement.

SUPPLEMENTARY INFORMATION

Nominated journal: Journal of Energy in Southern Africa.

<https://energyjournal.africa/>

Supervisor / Co-author: Dr. Lumkile Mondi

Word count †: 23115

Supplementary files: [APPENDIX A: Secondary Data Sources](#)

† Including abstract references, etc.

ABSTRACT

Eskom is struggling to consistently supply electricity as required by the country, therefore failing to keep the lights on. Eskom has been producing less and less power over the years, a wicked problem for an economy faced with poverty, unemployment and inequality. This wicked problem in the energy (electricity) supply system has impacted a large number of stakeholders. These include, mining, commercial and industrial, agriculture, households and the entire Southern African Power Pool and its customers. As a result, this energy insecurity problem of all the stakeholders is therefore considered as a wicked problem that does not have a straightforward solution.

This research investigates the impact and challenges in the economy and society at large as a result of wicked problem, energy insecurity, and assesses what can be done by the society to mitigate these challenges and then propose a solution to the identified problem in the form of Energy Mix Policy. It does so by using secondary data from multiple database sources.

This research argues that the energy insecurity (unreliable energy supply) in South Africa is a wicked problem. It affects multiple stakeholders from the business communities, government, industries, and everyone in the society, even touching climate change environmental management sectors. This also affects all economic industries, commercial businesses, water supply, hospitals, telecommunications, and transportation sectors, etc. as they all require power to operate, and therefore a solution would require all these stakeholders to be involved and act collectively together in finding a solution that can assure energy security for all.

Keywords: Energy Security, Energy Insecurity, Wicked Problems, Energy Mix Policy, Economic Development, Unemployment, Society, South Africa, Poverty.

CHAPTER 1: INTRODUCTION

1.1 Introduction

The term wicked problem was initially used by a German academic named Horst Rittel in the 1960s. A wicked problem is one that does not have a single clear solution, rather, it is viewed differently by different parties, and attempts to address it can cause further problems to arise (McGregor, 2011; Batie, 2008). Wicked problems are difficult challenges that do not have any generalizable methodologies to generate prospective solutions and that cannot be resolved in a predictable and straightforward manner, necessitating the use of multiscale approaches, strategic strategies, and more complete solutions (Huang et al., 2022; DeFries & Nagendra, 2017; Rittel & Webber, 1973). It didn't become widely used until the 1970s (Thollander et al, 2019).

This research argues that the energy insecurity (unreliable energy supply) in South Africa is a wicked problem. It affects multiple stakeholders from the business communities, government, industries, and everyone in the society, even touching climate change environmental management sectors. This also affects all economic industries, commercial businesses, water supply, hospitals, telecommunications, and transportation sectors, as they all require power to operate, and therefore a solution would require all these stakeholders to be involved and act collectively together in finding a solution that can assure energy security for all. It will not be easy, as in most cases, these stakeholders always have different interests and perspective of how the solution should look like for them and their benefits, forgetting the broader public, especially the poorer citizens.

There are several barriers that need to be overcome in order to make a switch to energy security right now. These barriers include the economy, the environment, and the infrastructure (Baker et al., 2014). Therefore, even though technological advancement may take place in stages, the constraints in the energy supply and surplus imply that trade-offs need to be made in order to accommodate the competing pressures of job protection, socioeconomic development, and addressing the historically disadvantaged population as well (Baker et al., 2014). We might conceive of the challenges experienced and processes of modifying the

South African electrical energy power system to fit the demands of our current and future cities as.

1.2 Background

Prior to the end of apartheid in 1993, just 36% of the population had access to electricity as a result of racial exclusion (RSA Parliament, 1994). Rural and urban population who had access to electricity around 1996 was at 23,8% and 85,3% respectively (RSA Parliament, 1994). Between 1994 and 2016, ESKOM, under the ANC Government increased access to over 88% of the country's population (INEP, 2022). This led to an increase in the demand of energy, as compared to the generation capacity infrastructure built.

More studies need to be conducted to address the “wicked problem” of alleviating energy poverty while also reducing carbon emissions in South Africa's energy sector and achieving the country's 2030 targets for becoming a greener economy. The insecurity of energy supply in Southern Africa is a wicked problem for two main reasons. First, by resolving the crisis, one could build a free and equal society by eradicating poverty, fostering economic growth, and eliminating unemployment. Second, one could ensure long-term sustainability by implementing mitigation for climate change strategies that concentrate on the energy sector. The issue with this, though, the fact that these two occurrences are not necessarily mutually exclusive. Poverty declines when income rises (a result of thriving enterprises and economic expansion), while emissions rise as a result of increased energy use to support economic growth. How can we build a system where emissions and poverty are reduced?

There has been very little investment to the energy generation infrastructure, between 1994 and 2006. The South African economy grew at a rapid pace between 2001 and 2007 with Quarters of economic growth last seen in the 1960s. This resulted in excess demand of electricity matching by constrained supply as a result of underinvestment. South Africa found itself with energy insecurity since ESKOM could not keep the lights on.

Eskom started implementing loadshedding late 2007 and became worse in 2008, and it has gotten worse over the years with 2021 and 2022 being the worse years South Africa has been hit by loadshedding.

The Electricity Generation has been reducing yearly, even though the demand has been declining (Andrade et al., 2020).

The energy sector in South Africa is distinguished by the abundant and low-cost generation of power from coal. Nevertheless, South Africa is presently dealing with an energy insecurity crisis that exhibits no signs of improvement in terms of the development, accessibility, or dependability. Electricity, or development that is particularly energy demanding, is a structural requirement for the economy. The political misalignment, infrastructure, and energy vision in South Africa all appear to conflict with one another, with the conflicting interests in the presidency and ministry of energy where it appears that the presidency is prioritising the variable renewable energy (decarbonisation), even when the whole world is falling back to Coal and Nuclear because of the Russia and Ukraine War, versus the ministry of energy who seems to be wanting to prioritise energy security (with Coal and Nuclear) as to keep the lights on and prioritise the economic development like all states Globally.

The course that has been established appears to be hampered by a number of different restrictions that prevent it from moving in a single direction. These include the lack of reliability in the supply of power may be traced back to poor management on the part of Eskom and local municipalities, meddling from the government, and a failure to take decisive action. Increasing insecurity concerns have led to an intermittent and costly supply of power to the country. These difficulties include ongoing corruption with the awarding of maintenance bids, cable theft as a result of high pricing and living standards in South Africa, and further demands from international communities for South Africa to move towards renewable energy sources in a more accelerated rate than the current REIPPP programs.

This has led to a decrease in the standard of life for the people who live there, as well as forced unfavourable changes in social and commercial behaviour, a rise in the cost of food, employment instability, and measures to provide social handouts

to compensate for the imbalance. Because of the unreliability of the country's electricity supply, several prospective domestic and international enterprises have decided not to invest in the country as a result.

In order to satisfy demand and maintain the integrity of the system, the monopolistic state-owned enterprises in South Africa have offered financial incentives to high-intensity industrial users to reduce the amount of output they generate. This has a significant impact on the GDP, particularly on the mining industry, which accounts for sixty percent of total exports. As a result, there is less money going into the country as a result of this.

The energy catastrophes which impacted South Africa in 2008 and consequential economic slowdown have also deterred further foreign investments from coming in that wanted to explore massive development in the country which would have been initially supported by a cheap and reliable stockpile of coal. These foreign investments wanted to come into South Africa but have been prevented from doing so by the electricity crises. The nation was then subjected to load shedding for the very first time. As a result, businesses in the manufacturing and mining industries were put at a disadvantage due to the fact that they were already bound by an electricity agreement, which required them to maximize efficiency and cut down on consumption by any and all means possible. However, residential and retail areas did not sign this agreement because electricity was inexpensive in those areas. As a result, there was no incentive or initiative on the part of these businesses to reduce their consumption of electricity or even seek alternative ways to generate different types of electricity.

As a result of the energy crisis, there has been a significant disruption in terms of psychological modifications to decrease the amount of power consumed. It is called a perverse method to load shedding, and it is used to minimize the amount of power consumed in order to stabilize the electricity system. Since it was first implemented, load shedding has had a profound impact on the economy.

The unscheduled reduction in load had a detrimental impact on the mining department. Manufacturing and retailing, however, were nonetheless impacted,

substantial losses were incurred by cold processing, and farmers were also hit with financial setbacks. This was the case even though load shedding had been anticipated.

Increasing the price is another method for lowering demand, and we have seen that this method has been utilized; nevertheless, it appears to be a catch-22 scenario when the price increases excessively fast and to an excessive degree. An increase that is executed too quickly will result in a rise in inflation, and as a result, a technique that is adopted step by step is required. However, if the rise in price is too little, there is not enough of a corresponding decrease in demand, and this puts a pressure on the system.

In addition, a reliable and uninterrupted electricity supply is essential in order to eliminate the poverty and unemployment that are currently affecting the rural and farming communities in South Africa.

1.3 Importance of Energy Security

Electricity security is extremely significant when considering all the other industries electricity gave birth to and industries it supplies worldwide, day in day out and the logistic and support industries that supply it. The electricity industry in South Africa is heterogeneous in structure, in technical and environmental standards as well as in global networking. Nevertheless, all subdivisions of electricity industry have the same challenges for the future, which arise from environmental standards, socio-economic issues of the country, theft, infrastructure-vandalism and globalisation in the energy markets. However, the South African electrical energy industry also has some unique problems based on regional structures of production and markets.

1.4 Research Problem Statement, Questions and Propositions

Eskom is struggling to consistently supply electricity as required by the country, therefore failing to keep the lights on. Eskom has been producing less and less power over the years, a wicked problem for an economy faced with poverty, unemployment and inequality. This wicked problem in the energy (electricity) supply system has impacted a large number of stakeholders. These include, mining, commercial and industrial, agriculture, households and the entire Southern African

Power Pool and its customers. As a result, this energy insecurity problem of all the stakeholders is therefore considered as a wicked problem that does not have a straightforward solution.

The implementation of extensive load shedding since capacity expansions and increases have not been sufficient to stem the loss in produced electricity, has led to other unintended consequences, slowdown in industrialisation, destroying small and medium enterprises and jobs.

This research investigates the impact and challenges in the economy and society at large as a result of wicked problem, energy insecurity, assesses what can be done by the society to mitigate these challenges. It does so by using secondary data from multiple database sources, industry, surveys/interviews, and research papers available online and in the University of the Witwatersrand Library.

1.4.1 Research Questions

The proposed research questions that are considered to address the research problem are:

- 1) What has been the economic, social, political, and environmental impact of the energy insecurity in South Africa?
- 2) What strategies can be used and implemented to improve and mitigate further energy insecurity in the future of South Africa?

1.4.2 Research Propositions

The research propositions based on the questions above for the research questions above.

- 1) Energy insecurity in South African has had severe and detrimental economic developmental impact. This wicked problem has given rise to a wide range of social, economic, political and environmental challenges in the country that necessitate multi-stakeholder collaborative careful examination and intervention.
- 2) To effectively address energy insecurity and ensure a secure energy supply for South Africa's economic development, effective decision-making

necessitates collective collaboration among different stakeholders, including government officials, energy industry, experts, and representatives from economic, social, political, and environmental sectors who are involved in energy policy and implementation strategies. It is important to expand the focus beyond decarbonization and prioritize meeting the nation's energy security needs.

1.5 Research Focus, Scope, and limitations

This research project focuses on energy in the form of electricity and evaluates the wicked problem of energy insecurity. Furthermore, it investigates the impact and challenges in the economy and society at large as a result of energy insecurity, and what can be done by stakeholders to mitigate these challenges.

The research work is mostly desk top research, using secondary data from multiple statistical databases, and primary data from surveys/interviews where necessary and stakeholders' input from the energy industry and in Government who make the Energy Policies. The main outcome for this research project is a dissertation report identifying and describing fit technological solutions, and drafting energy policy recommendations, which would assist in trying to address the energy insecurity problems facing South Africa.

This research does not analyse in detail the related energy topics like energy efficiency, electrification, energy technologies analysis, energy equity, energy policy, and energy pricing etc.

1.6 Conclusion

The research project aims to enlighten stakeholders about the major social, economic and challenges caused by energy insecurity and provide prospective benefits of mixed energy technologies, by facilitating relations among all stakeholders including policymakers, industry stakeholders, leaders, and academic researchers to endorse deployment of the energy mix systems that will improve energy security.

CHAPTER 2: RELATED LITERATURE AND DISCUSSION

2.1 Introduction

Energy is an essential resource that is necessary to produce products and services and the improvement of personal, societal, and economic well-being (Global Energy Institute, 2018). It is necessary for the manufacturing of products and services across a variety of businesses, as well as for the movement of people and goods, as well as for the heating, lighting, and operation of different home appliances in private residences.

Energy is the engine that keeps the economy moving forward. Energy, business, the economy, growth, and overall development are all essentially reliant on governmental need, available capacity, and affordable pricing. Demand and growth are both dependent on a number of factors, the most important of which are public health and safety.

2.2 Energy Security

The issue of energy security has been around since the 1970s (Zhiznin et al., 2020), but there is no universally accepted definition, even though the subject of is recognized as a vital aspect of the current economic and political discourse. The definition of the phrase has changed over the course of more than four decades (Zhiznin et al, 2020).

According to the definition provided by the Copenhagen School, “security” refers to “a serious threat to a specific item” (Buzan et al., 1998, p25).

According to the Energy Security Master Plan-Electricity published by the South African Department of Minerals and Energy for the period 2007 to 2025, Energy security is defined as “ensuring that diverse energy resources, in sustainable quantities and at affordable prices, are available to the South African economy in support of economic growth and poverty alleviation, taking into account environmental management requirements and interactions among economic sectors” (DMRE 2007a:13) and as also cited in Trollip et al., (2014,p.5).

Energy security reflects different notions in different countries and situations (Jewell and Cherp, 2014).

According to the International Energy Agency, (1974) energy security, is “uninterrupted availability of energy sources at a reasonable price”.

Winzer (2012) observes that the context is typically incorporated into the definition of energy security. Winzer (2012) adds that in a number of emerging nations, the objective of energy security has been to shield the poor from commodity price instability. Energy security is defined by him as the continuity of energy supplies relative to energy demand.

Energy security, according to Cherp and Jewell (2011), is an example of security in general and is defined as “low vulnerability of vital energy systems”.

Energy security, according to Andrews (2005) and Jun et al. (2009), entails ensuring enough, reliable energy supply at acceptable rates and without jeopardizing important national values and goals.

Energy security, as defined by Intharak et al. (2007), is the capacity of an economy to ensure the availability of energy supply in a sustainable and timely way at a price that does not hinder economic performance and development.

Energy security, according to (APEREC) Asia Pacific Energy Research Centre (2007), comprises of the four A's: accessibility, availability, affordability, and acceptability.

The energy supply is often the designated item within the context of the energy securitization framework (Zhiznin et al, 2020). The International Energy Agency (IEA) distinguishes between two separate types of energy security: prolonged (long term) and short-term. Long-term energy security, which focuses largely on the need to make current investments in energy supply; economic development; and sustainable environmental needs (Zhiznin et al, 2020). Short-term energy security is based on the energy system's ability to respond rapidly to sudden fluctuations caused by the supply-demand mismatch (IEA, 2014a).

Energy security, according to this view, is based on dependability, affordability, competitiveness, and physical availability of supplies (IEA, 2014a) and is centred on the customer (Zhiznin et al, 2020).

The World Energy Council (WEC) suggests minor modifications to the International Energy Agency's (IEA) concept and emphasizes that energy security is one of the three core dimensions of the Energy Trilemma (energy equity, energy security, and environmental sustainability (Zhiznin et al, 2020). The council defines energy security as the “efficient management of primary energy supplies derived from both internal and external sources, the dependability of the energy infrastructure, and the capacity of energy supplying organizations to satisfy both the present and the anticipated demand in the foreseeable future” (World Energy Council, 2014, p11). However, affordability is not included in this definition, as the Agency has moved the concept of affordability to a different dimension of the energy trilemma, namely to the concept of the fair allocation of energy resources.

Chester (2010) referred to the idea of energy security as “polysemic” and “slippery,” two terms that he used to define the notion (Månsson et al., 2014). This is because various stakeholders have varied ideas about what security entails and how it can be brought up to an acceptable level (Månsson et al., 2014). This variability can be attributed to variations in how various stakeholders appreciate the importance of distinct parameters, such as decentralization of supply and energy intensity (Bambawale & Sovacool, 2011), as well as differences on a national level, such as whether the stakeholder's country is resource-rich or a net importer (Bradshaw, 2010), as cited in Ayoo (2020) and if the primary focus in the country is on market economics or government oversight. In industrialized nations and underdeveloped nations, energy security tends to be more directly tied to the supply of access to energy to the underprivileged in rural parts of the country, and in the third scenario, access is provided for the fast-increasing industry and service sectors in urban areas (Månsson et al., 2014; Kuik et al., 2011).

Energy security is dynamic, with different perspectives on stability and cost effectiveness (Månsson et al., 2014; von Hippel et al., 2011). This has led to a

discussion among academics over how the state of energy security will evolve over time and the most effective ways to adapt (Ciută, 2010).

Johansson (2013) suggested that there is a distinction between the following scenarios:

- i) when the energy grid is analysed as an attribute that is subjected to threats, which is commonly referred to as “security of supply” or “security of demand,” and
- ii) when the energy system functions as an intermediary that creates or improves (in)security, for example as a result of a presumed political or economic value (Månsson et al., 2014).

Energy security studies should focus on the many aspects that influence security, as it is unlikely, and maybe even undesirable, to reach an agreement on a single definition and understanding of energy security.

Winzer (2012) proposed that energy security should be distinguished from other policy objectives by defining it as “the continuity of energy supplies relative to demand”, thus narrowing the concept to “security of supply.” Therefore emphasizing the need for a safe supply chain (Månsson et al., 2014).

Energy security reflects different notions in different situations and countries due to its own energy system characteristics (Jewell and Cherp, 2014). On the other hand, because this phrase has not been defined in its whole, it is difficult to quantify it and strike an equilibrium between it and other political ambitions.

A clear conceptualization of energy security is essential for an efficient and effective pursuit of this policy goal.

2.3 Understanding energy insecurity as a wicked problem

Energy insecurity is the inability to meet the energy demands of homes, businesses, and communities, resulting in negative environmental, social, and behavioural effects (Hernández, 2016). Bohi and Toman (1993;1996) as cited in Ayoo (2020),

defined energy insecurity as “the loss of welfare that may occur as a result of a change in the price or availability of energy.”

A wicked problem is a complex social or socio-economical issue that is best described by the complexity of formulation of the problem and the multidimensionality of various stakeholder groups associated with identifying and tackling the problem (Niskanen et al., 2021). The term “wicked problems” is frequently used to describe these types of issues because of their complexity. A wicked problem is characterized by its contentious, one-of-a-kind, difficult to solve, and emergent characteristics, making it difficult to predict the implications of any solutions (Rittel & Webber, 1973).

Wicked problems are difficult to solve due to incomplete, conflicting, or ever-shifting needs. They have been used as a paradigm for understanding a variety of issues, such as the difficulty of mitigating the effects of climate change (Rittel & Webber, 1973). It is difficult to articulate them and come to a decision on how to best address them.

Even when they are the product of public discourse and shared concerns, the actions taken to minimize the problems are frequently insufficient and only provide a temporary solution (Rittel & Webber, 1973).

According to Rittel and Webber (1973: pg. 156, 159 and 160), scientific and technological approaches to identifying and solving such “problems of open societal systems” would thus be worthless. Figure 1 below presents the first ten elements of wicked problems that Rittel and Webber (1973) identified as being prevalent in these types of issues.

1. There is no definitive formulation of a wicked problem
2. Wicked problems have no stopping rule
3. Solutions to wicked problems are not true-or-false, but good-or-bad
4. There is no immediate and no ultimate test of a solution to a wicked problem
5. Every solution to a wicked problem is a “one-shot operation”; because there is no opportunity to learn by trial-and-error, every attempt counts significantly
6. Wicked problems do not have an enumerable (or an exhaustively de-scribable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan
7. Every wicked problem is essentially unique
8. Every wicked problem can be considered to be a symptom of another problem
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem’s resolution
10. The planner has no right to be wrong

Table 1: Elements of wicked problems as presented by Rittel & Webber (1973), (Niskanen, 2021).

These wicked challenges have been simplified and refined further by other writers, such as the five features described by Conklin (2006), as well as by Levin et al (2012) who presented the super wicked problems.

Nonetheless, the resurrection of the notion in the 21st century illustrates that academics have discovered that it connects with the complicated difficulties that are confronting modern communities (Danken et al., 2016).

2.4 The link between Energy insecurity and wicked problems

The modern electrical energy system is under strain due to rising demand, prevalence of population socioeconomic inequality, and climate change challenges. Traditional approaches to reducing energy insecurity are insufficient to meet the need.

In spite of the substantial resources that have been committed towards solving the problem, several of the policy difficulties that majority (if not all) governments are currently facing are really complicated, politicised, controversial, and appear to be unsolvable (Clark & Stewart, 1997). There is no resolution that is readily apparent or easily established (Coyne, 2005). Challenges such as climate change, poverty, inequality, crime, infrastructure theft and vandalism, and apartheid caused disadvantages are some manifestations of these policy difficulties in South Africa.

There are a number of distinguishing features that may be used to identify wicked problems; however, not all of these features are required for a situation to be considered wicked (Roberts, 2000).

2.5 Energy Security for modern functioning of economies and societies

It is common practice to allude to the “security of supply” of electricity, which is another euphemism for “keeping the lights on,” while discussing the issue of electricity security (IEA, 2020). The ultimate objective is to supply consumers with power in a dependable manner and at a price that is affordable (IEA, 2020). There are a lot of things that may go wrong on the way to achieving this goal, from the equipment breaking down and running out of fuel to errors in the operational planning, people making mistakes, and malicious attacks.

The following is the definition that is used by the IEA: Electrical security refers to the capacity of the energy system to withstand and recover from disruptions and unforeseen circumstances, therefore ensuring that there is continuous supply of electricity (IEA, 2020).

Energy security (Electricity) is the consolidation of all actions taken, including those that are economic, technical, and legislative in nature, through the objective of maximizing the mark of security in the context of both the short-term and long-term effects of the energy transition, cyber events, and climate change (IEA, 2020).

The power industry is undergoing essential shifts, such as decarbonization, digitalization, and changes in climate change, which are leading to an increase in

the frequency and severity of extreme weather events (IEA, 2020). To ensure a reliable energy supply, governments, businesses, and other stakeholders need to update their frameworks, such as the legislation, regulations, and market structures that regulate the industry, to ensure security.

Electricity is essential for the digital economy, even though it only makes up a fifth of primary energy consumption in the world (IEA, 2020).

Recent challenges brought on by the Covid-19 global epidemic serve to bring to our attention the critical role that electricity plays in every facet of life, such as ensuring that medical equipment in hospitals continues to function properly and that information technology networks are accessible for remote communications and working or popularly known as “working from home” (Madurai et al., 2020). The effects of a power outage that lasts for an extended period of time go well beyond the real worth of the loosing electricity purchase in and of itself (IEA, 2020).

2.6 Importance of energy security

Electricity Generation, Transmission and Distribution are essential for all economies, providing essential services such as healthcare, communication, banking, transportation, and manufacturing (IEA,2020). The Electricity industry has been slow to make use of the mixture of technologies needed to meet the high demands of electricity. However, it has been studied and observed that a careful mixture of technologies can be effective in reducing carbon footprint, increasing penetration of intermittent renewable energy, and ensuring security of supply for industries that improve and encourage economic development for those parts of the world, by finding different alternatives to address the baseload challenges.

Typically, wicked problems are the result of the interaction of multiple stakeholders, each of whom has their own unique set of values, perceptions, and options. Similarly, to try and tackle wicked problems requires the participation of multiple and all stakeholders to act together, hence in the next section I discuss stakeholder theory, as the South African energy insecurity will require the simultaneous use of a variety of strategies and methods drawn from a wide range of fields in order to resolve wicked problem.

2.7 Stakeholders Theory

The stakeholder theory of managing organizations is a major paradigm shift (Amaeshi & Crane, 2006) that examines the interaction between both the company and its stakeholders (Ayuso, et al., 2006). It is based on Freeman's (1984) definition of stakeholders, which states that “any group and individuals who can affect or is affected by the achievement of an organization's objectives” (Freeman, 2010, p. 46). This term was especially significant to this research since it brought to light the fact that the interaction between the organization and its stakeholders is a two-way relationship.

Stakeholders are structures that either impact or are influenced by an organization's decisions (Bryson, 2007; Petkov et al., 2007; Grimble & Wellard, 1997). They are “anyone who affects or is affected by operations of a company” (Reed et al., 2009: 12).

Stakeholder theory focuses on the goals of an organization and divides stakeholders into categories according to the goals of the company (Marcon Nora et al., 2022; Freeman, 1984). Only individuals or groups of persons are considered interested parties when seen through the lens of stakeholder theory (Phillips & Reichart, 2000; Freeman, 1984).

Stakeholder analysis is a technique used to understand the positions of stakeholders and their relationships with decision-making, as well as their requirements, goals, and potential conflicts. (Aly et al., 2019; Reed et al., 2009; Grimble, 1998). Stakeholder analysis identifies major stakeholders (Aly et al., 2019) and their impact, interrelationships, and decision-making objectives, providing a starting point for decision support tools (Reed et al. 2009; Bryson, 2004; Grimble, 1998).

Being able to categorize key stakeholders focusing on their relevancy scale is beneficial for assessing the potential impact of a certain stakeholder group on the decision-making process in a complicated multi-stakeholder (Aly et al., 2019), wicked problem such as energy insecurity. According to stakeholder models,

companies have a responsibility to be aware of the diverse needs of their constituents and respond appropriately to those needs (Post et al., 2002).

Organizations should focus their efforts on developing “relationships between organisation and stakeholders” (Greenwood, 2007, p.318), for both normative and instrumental reasons which are essential for the success of the organization (Ayuso et al., 2006; Donaldson & Preston, 1995).

Managers have a responsibility to take into account the interests of stakeholders who have a legitimate stake in the organization (Ayuso et al., 2006; Preble, 2005). According to normative theory, the organization has a moral duty to interact with stakeholders (Greenwood, 2007; Preble, 2005), and people have a democratic right to participate in the decision-making process. Instrumental theory views stakeholders as important in helping organizations accomplish their goal (Donaldson & Preston, 1995; Preble, 2005). This view contrasts with the view that democratic theory takes of stakeholders.

Stakeholders are any individuals or groups with interests in an organization, and Donaldson and Preston's (1995) definition implies that all stakeholders have value and deserve equal treatment. Greenwood (2007) argues that the debate on the relationship between stakeholders and the organization has shifted to identifying stakeholders, and that if an organization does not build filters to differentiate between key and less crucial stakeholders, the dialogue must encompass everyone and everything (Strydom, 2016; Pedersen, 2006). Critical stakeholders must be identified and selected based on criteria that differentiate them from other vital stakeholders (Strydom, 2016; Pedersen, 2006; Preble, 2005).

Figure 1 below is high level diagram that shows the stakeholders of the South African Energy sector, which help highlight the complexity and interdependencies of multiple industries and stakeholders which in many instances have different and conflicting goals, which would create a challenge for the sector in order to provide energy security for the country's economy.

We have the South African Government, which is a public entity with multiple departments responsible for a variety of policy directives, high level decision-

making, which sometimes contradict each other as they departments have different objectives, as well as different role players that in many cases would impact one another. Within the scope of the Government departments, we have two critical entities, directly driving the energy sector, which is the department of mineral resources and energy (DMR&E) and National Energy Regulator of South Africa (NERSA).

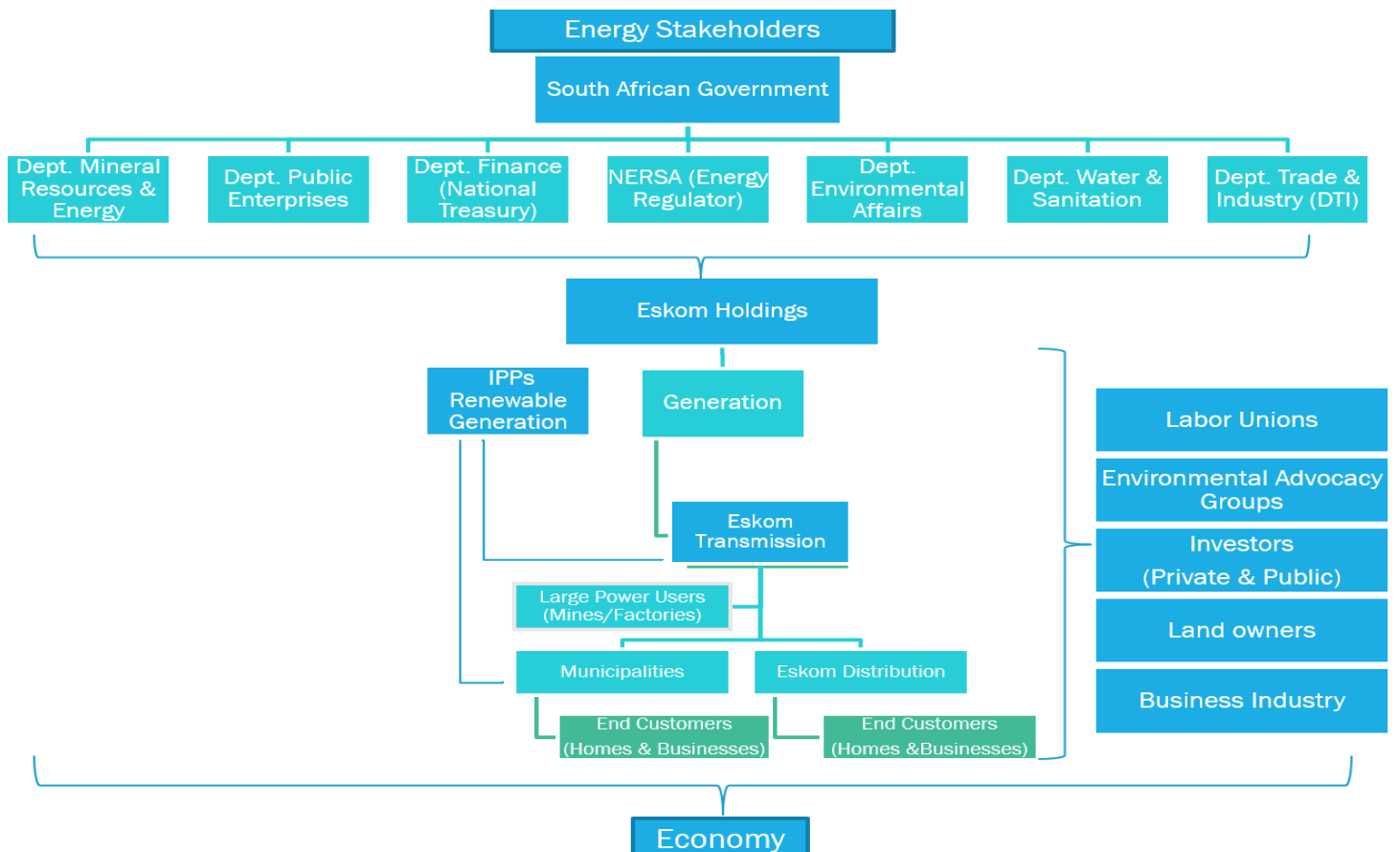


Figure 1: Stakeholders of the South African Energy (Electricity) Sector

Source: Authors' Own Analysis

DMR&E is “mandated to ensure the transparent and efficient regulation of South Africa's mineral resources and minerals industry, and the secure and sustainable provision of energy in support of socioeconomic development” (DMRE, 2022a) and it is also anticipated that this would increase the engagement of the private sector in the energy industry (DMRE, 2022b).

NERSA is “mandated to regulate South Africa's electricity, piped gas and petroleum industries and to collect levies from people holding title to gas and petroleum (DMRE, 2022b)” but is not limited to this, as NERSA’s responsibilities also include:

- iii) The administration of licenses, the establishment and approval of tariffs and charges, the mediation of disputes, the collection of information pertaining to the energy industry as a whole, and the promotion of the most efficient use of energy resources are all responsibilities of an energy regulator (DMRE, 2022b).
- iv) NERSA's role as an economic regulator will require it to maintain a fair playing field and guard against abuses committed by monopolies (DMRE, 2022b).
- v) The regulator is essential because it will foster more access to the market and competitiveness in a market that is dominated by single major players, like Eskom in the Electricity sector (DMRE, 2022b).

Then there is Eskom Holdings which has Generation, Transmission and Distribution as sub-entities.

Eskom is mandated “to provide electricity in an efficient and sustainable manner, including its generation, transmission and distribution and retail” (Eskom, n.d.). The company also has a developmental role and will promote transformation, economic development and broad based black economic empowerment (DPE, n.d.).

Eskom is responsible for producing and distributing electricity to residential, commercial, industrial, agricultural, and mining clients, as well as municipalities or redistributors (DPE, n.d.).

Municipalities distribute power to end users (residential and business) and Independent Power Producers (IPPs) Generate power from renewable energy sources.

Labour unions (i.e., COSATU) which represents employees and ensure they are compensated and treated fairly by the employers like Eskom Holdings.

There are environmental advocacy groups, which are environmental civil societies and activists who promote healthy environment, environmental protection, and companies recognizes the interdependence of people and the environment, by making sure the use of fossil fuels (Emissions reduction) is reduced, greener technologies (Increased renewable energy penetration) are used (Centre for Environmental Rights, n.d.). This is part of their effort to realize the constitutional right to a healthy environment.

We then have the Private and Public investors and Business industries who invests money into the energy sector and consumes large quantities of energy and also play a key role with all the above stakeholders in the development of the South African Economy.

2.8 Conclusion - Critical Review Assessment of Literature

The subject of energy supply security is recognized as a vital aspect of the current economic and political discourse, but there seems to be no universally accepted definition that has already been acknowledged amongst international community.

Energy security is the availability of diverse energy resources to support economic growth and poverty alleviation, taking into account environmental management requirements. Different countries have different energy system characteristics, leading to different definitions of energy security.

Energy security is defined globally as the inability to meet the fundamental energy demands of homes, businesses, and communities, with its associated negative environmental, social, and behavioural effects.

A clear conceptualization of energy security is essential for effective policy implementation.

A wicked problem is a complex social or socio-economical issue that is best described by the complexity of formulation and multidimensionality of various stakeholder groups. This is exemplified by the electrical energy system stakeholders (Figure 1), which have different and conflicting goals. This creates a challenge for the sector to provide energy security for the country's economy.

Global energy insecurity is a result of public discourse and shared concerns, and actions taken to minimize it are often insufficient or worse depending on the angle of perception. Government policy difficulties are complex, politicised, controversial, and appear to be unsolvable.

Wicked problems in electrical energy security and insecurity have not been studied much globally, particularly in Southern Africa, and their consequences to societal social and economic issues.

Wicked problems in developing countries have not been thoroughly studied, even though scholars like Niskanen, V.P., Rask, M., & Raisio (2021) have studied “Wicked Problems in Africa”. This paper highlighted multiple the wicked problems but did not include any studies in the realm of energy, nor mention the subject of energy security/insecurity.

Energy insecurity is also a subject that has not been studied nor discussed much directly but has been studied with reference to energy security globally, but in the Southern Africa it hasn't been a focus, as well as the societal social issues that arise because of energy insecurity have also not been tackled.

These are some of the many gaps in the concepts of wicked problems and energy insecurity, my research is tackling.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This Chapter outlines the research methodology used to study the wicked problem of energy insecurity in South Africa, including the research design, appropriateness of the research method, research sample, instruments used, data collection, data analysis and delimitations of the research.

3.2 Research design method

This research project is characterized as qualitative, descriptive, non-experimental analytical research, and its technique is mostly based on a systematic literature review and case study research. The research design for the study is depicted in Figure 2 below. Secondary data was gathered for the study from a variety of sources, mostly from reports and charts/data prepared by ESKOM, the World Bank, World Economic Forum, to analyse and answer the questions and confirm propositions. The sources include but are not limited to the ones detailed in APPENDIX A below.

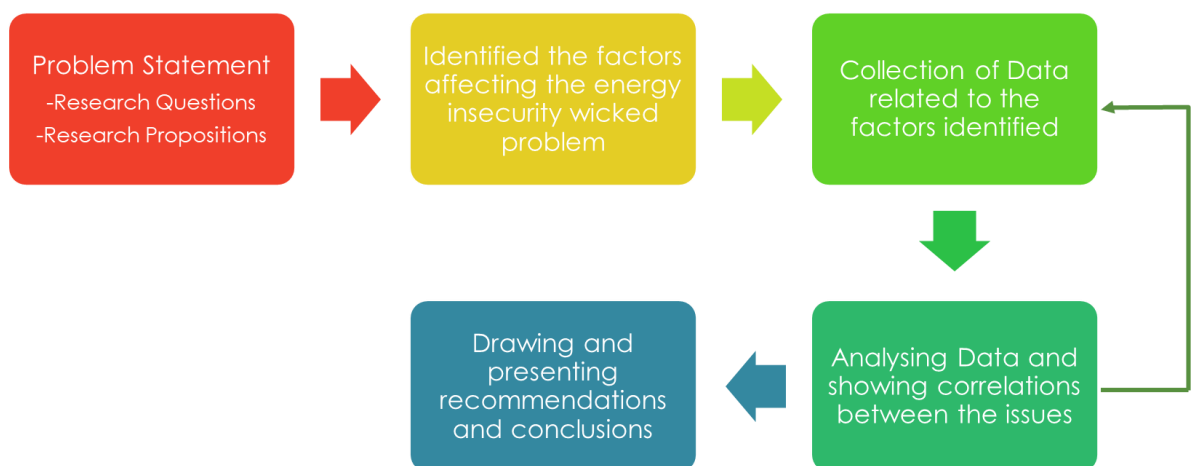


Figure 2: Iterative Research design method steps.

Source: Authors' Own Analysis

The first two phases, according to the design model that is provided in Figure 2, consist of first outlining the research problem statement, with its associated research questions, and then identifying the dominant factors that are contributing

to the wicked problem of energy insecurity. After this step, the collection of secondary data, from different sources as detailed in the annex, then the analysis of the secondary data and key factors are analysed with reference to the research questions and the propositions made for the study, which all lead to the results of the study, and the presentation of the solutions to the problem statement and finally the conclusions are drawn from the study.

3.2 The appropriateness of the research method selected

An exploratory, descriptive and explanatory studies are the three types of research. The purpose of exploratory research is to gain “new insights, ask questions and to assess topics in a new light” (Saunders & Lewis, 2012, p. 110), while the focus of descriptive research is to provide “an accurate representation of persons, events or situations” (p. 111), and the objective of explanatory research is to “studying a situation or problem in order to explain the relationship between variable” (p. 113) as also cited in Strydom, (2016).

The literature evaluation is referred to as a systematic review of the literature (Voorberg et al., 2015; Gjaltema et al., 2019;). A systematic literature review is defined as “review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review.”, as stated by The Cochrane Collaboration (2015). Whereas “traditional” literature reviews are employed for argumentative objectives by picking which pieces of literature to evaluate, systematic literature reviews are “methodical, complete, transparent, and reproducible,” and are therefore possibly less biased than traditional literature reviews (Siddaway et al., 2019, p. 751).

Because the focus of the study is on the utilization of the idea of wicked problems, throughout the entirety of the published literature on South Africa with an extension to Africa, rather than just in the research outcomes, this is the technique that will be used for the literature review.

According to Rajasekar et al. (2006), qualitative research focuses on meaning, sentiment, a description of the situation, applies logic, is exploratory, and examines the why and how of decision-making (Strydom, 2016).

This in-depth explanatory data would then be used for to identify factors affecting/causing the challenges in question. An analysis will be done to draw out patterns from concepts and insights into the research problem. Illustrative results & recommendations of solutions to the research problem.

An exploratory case study will be undertaken to address the impacts of energy insecurity in the economic, social and environmental perspectives and as well as looking at what can be done by the country at large to mitigate the energy insecurity in the short, medium and long term. To address the

3.3 Research Population Sample

Saunders et al., (2012, p. 1320 defined population as “the entire collection of members of the group”. The population analysed for this study comprised of all the individuals/stakeholders who use energy, either from an economic or social perspective, and who are thus exposed to the present electricity supply problem. This group included, but was not limited to, officials from Regulatory bodies like NERSA, environmental agencies, Eskom Holdings, multiple departments in the ministry of South African Government, Independent Power Producers (IPPs), members of the general public and energy consultants.

3.4 Instruments used in research

This research will be completely based on desktop research conducted through qualitative systematic literature review and case studies is said to be very descriptive, as it draws from a wide variety of information sources, as stated by Hancock and Algozzine (2006). These information sources come from significant participants in the study, in addition to additional literature, tools, and methods that were utilized to bring the research to life. One of the unique characteristics of the case study technique, according to Baxter et al. (2008), is the capacity to employ

numerous sources of information, which eventually boosts the trustworthiness of the data.

These various publications may consist of journal articles, technical and non-technical material, a documentary review, a personal interview, artifacts, personal observation, and surveys, which enable the integration of data at analysis stage. This is considered as a way to increase the robustness of the study in the sense that every data source would be seen as a component of the jigsaw that is finally braided with each other to allow for improved knowledge of the phenomena of interest.

Since the purpose of the research is to conduct an in-depth analysis of energy insecurity as a wicked problem in South Africa, the design of the study that will be used is both literature review and an explorative case study.

- 1) The South African economic, social and environmental impact of the energy insecurity in South Africa
- 2) It is important that the South African Integrated Resource Plan be relevant to improve or mitigate further energy insecurity going into the future of South Africa in order to assure both the economic growth of South Africa and the fundamental needs of mankind.

The complexity of all the players involved and effected as a result of South Africa's energy instability would necessitate the utilization of an integrated case study approach for the research. The laws, policies, academic literature, media comments, archival data, technical and non-technical studies, that will make up the majority of the sources of evidence will be the government's including Eskom.

3.5 Data Collection

According to Kabir (2016), the purpose of all data collecting is to acquire high-quality evidence that translates into rich data analysis and enables the construction of persuasive and believable responses to given questions.

“Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes” (Kabir, 2016, p. 201).

Methods of collecting qualitative data play a significant part in the process of impact evaluation because they provide information that is valuable for understanding the processes that are behind observable results and assessing changes in people's views of their own well-being (Kabir, 2016).

Secondary data, from reports, charts, actual data and other statistical data prepared by ESKOM, the World Bank, World Economic Forum, Government Agencies, like Stats SA, etc. was used to visualise graphically the impact of energy insecurity, related to the factors identified for the research questions, then the analysis of the secondary data and key factors will be analysed with reference to the research questions and the propositions made for the study, which would all lead to the results of the study, and the presentation of the solutions to the problem statement and finally the conclusions will be drawn from the study.

Sources and raw data utilised for the study will be kept. Not only will this make it possible for future researchers to do more study in the subject, but it will also contribute to the research's credibility. In order to enable for independent evaluation of the planned research findings, a dedicated research database with raw data format will be kept utilize. This database will contain all data, documents and information used in addition to other sources of data. To provide credibility to any conclusions that may be drawn from the investigation, it is essential to preserve a solid chain of evidence. In order to facilitate the successful integration of research problem to outcomes, results, and conclusions, a significant amount of emphasis will be placed throughout the actual thesis on providing comprehensive citations of all used material, journal papers, databases, as well as other sources of evidence.

The study period considers from around 1996 to 2022, with major focus on the years 2007 to 2022, when South Africa started experiencing energy supply challenges, but some data may range to years before 1996 and 2007. All the data collected for this study, was collected as secondary data from multiple sources as listed in Appendix A and referenced in text accordingly. The purposes of all the secondary data collected was for the purposes of answering the research questions and testing the propositions made for the study.

3.6 Data Analysis method

The data analysis to be used to for this research is a descriptive analysis. Descriptive analysis involves summarizing and presenting data in a meaningful way to provide an overview and understanding of the data (Cote, 2021), It involves using current and historical data to identify trends and relationships and is considered the simplest form of data analysis because it merely describes trends and relationships without delving further (Cote, 2021).

In this research, the data is presented using various figures and statistics to describe the access, generation, and consumption of electrical energy in South Africa. The data is analysed and presented in the form of percentages, trends, comparisons, and historical values. The figures and statistics provide a descriptive summary of the data, allowing the audience to understand the current state of energy insecurity in South Africa and its impact on the population.

Descriptive analysis is useful in this context as it helps to identify patterns, trends, and relationships in the data without going into complex statistical modelling or hypothesis testing. It allows for a clear and concise presentation of the key findings, making it easier for the audience to interpret and comprehend the results.

The data was collected for the purposes of answering the research questions, which asks,

- 1) What has been the economic, social, political, and environmental impact of the energy insecurity in South Africa?

2) What strategies can be used and implemented done to improve and also mitigate further energy insecurity going into in the future of South Africa?

According to Miles and Huberman (1994:10), qualitative analysis involves “three concurrent flows of activity: data reduction, data display, and conclusion drawing/verification” Figure 3 reproduces their ‘interactive’ model illustrating the circular structure of qualitative work. Importantly, they emphasised:

- 1) Every one of these three elements persists during and following data collection.
- 2) Data reduction requires analytic decisions and is therefore a component of data analysis.
- 3) Data presentation assists to organise and condense information, making it susceptible to even further interpretation and analysis.
- 4) Meanings derived from the data must be evaluated against the data, and if required, further meanings must be sought.

Analysis of data is a cyclical process that advances via a series of interactive stages. It incorporates a two-steps-forward, one-step-backward progression over three key sectors, constantly aiming for an in-depth comprehension of the cases and investigation issue.

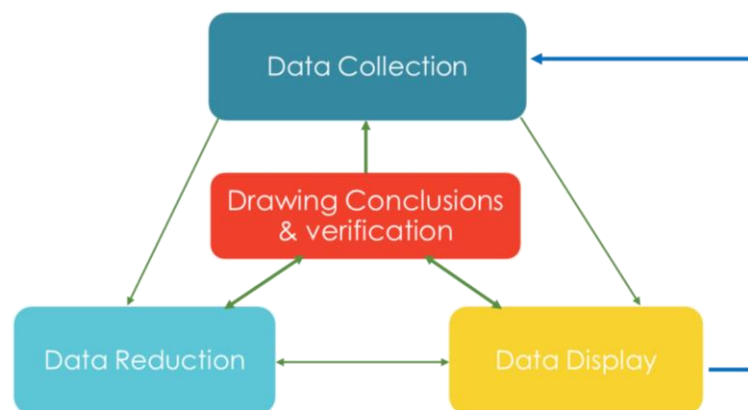


Figure 3: Reproduced & Modified Miles and Huberman’s Data Analysis Components Model, Source: Miles & Huberman, 1994:12, Figure 1.4

According to Hancock and Algozzine (2006), it is essential to adhere to the following rules in order to establish the credibility of the information analysis:

1. carrying out checks to determine the dependability of internal reliability assessments,
2. identifying any potential biases in the research that might distort the results, and
3. Analysing the collected results in relation to those of previously published studies.

The results will be based on the veracity of the publicly obtained secondary data, including papers, websites and journals from e-libraries as indicated in list appendix A.

3.7 Limitations of the research Delimitations

The internal validity of this study will be carefully guarded from being undermined by any external or internal variables. It is important to point out that the limits of the study may make it susceptible to criticism, but they may also present chances for more in-depth research in the future.

Geographical Delimitation: The research focuses specifically on the energy insecurity issue in South Africa. It does not consider energy insecurity in other countries or regions.

Stakeholder Delimitation: The research primarily focuses on the impact and challenges faced by stakeholders in South Africa, including mining, commercial and industrial sectors, agriculture, households, and the Southern African Power Pool and its customers. It does not extensively explore the perspectives of stakeholders outside of these sectors.

Methodological Delimitation: The research relies on secondary data from multiple database sources, industry reports, surveys/interviews, and research papers available online and in the University of the Witwatersrand Library. It does not involve primary data collection through fieldwork or direct observations.

Time Delimitation: The research primarily examines the energy insecurity problem in South Africa up until the present time (Up to February 2023). It does not delve into historical developments before the end of apartheid in 1993 or future projections beyond the current situation.

Solution Delimitation: The research aims to propose a solution to the identified energy insecurity problem in the form of an Energy Mix Policy. It does not explore alternative policy options or extensively analyse the feasibility and implementation challenges of the proposed solution.

Language Delimitation: The research is conducted in the English language, and it primarily draws on sources available in English. This may limit the inclusion of relevant literature or perspectives published in other languages.

3.8 Conclusion

The research design for the study is based on a secondary systematic literature review and case study research. Qualitative research is used to gain insights, ask questions, and assess topics in a new light. Multiple Secondary data sources will be used to acquire high-quality evidence that translates into rich data analysis. The data collected may not always be value neutral. The research does not cover the complete spectrum of all aspects of energy.

CHAPTER 4: DATA ANALYSIS AND RESULTS

4.1 Introduction

This chapter looks at the data analysis and results of the data for the research questions posed in the text, which ask about the economic and social impact of energy insecurity in South Africa, and what can be done to improve or mitigate further energy insecurity. The analysis of the data follows a cyclical process of data reduction, data display, and conclusion drawing/verification. The results are based on publicly obtained secondary data from papers, online databases, websites, and journals.

4.1.1 South Africa's Electrical Energy Access Data Analysis

In 2020, 84.39% of the population in South Africa had access to electricity, a 0.61% decline from 2019 and 0.3% increase from 2018 (World Bank, 2020). Studies have shown that access to electricity has a positive effect on income inequality in South Africa (Sarkodie, Adams, 2020). Globally, 770 million people still lack access to electricity, mostly in Africa and Asia (IEA, 2022). Low access to electricity is also linked to income inequality in South Africa (Sarkodie, Adams, 2020).

In South Africa, 85 percent of the nation's electricity is generated via coal-fired power plants (world Bank, 2020), while renewable sources such as solar and wind account for only a small fraction of the total energy production (world Bank, 2020). South Africa has one of the highest rates of electricity access in sub-Saharan Africa (IEA, 2019).

To understand the impact the energy insecurity has in the South African population at large, we need to understand how much of the population has access to electricity, and this data is source from the World Bank, Eskom Holdings and as well as DMRE as referenced.

A significant majority of the South African population has legal access to electricity as it can be observed on Figure 4 below, this excludes all the illegal connections.

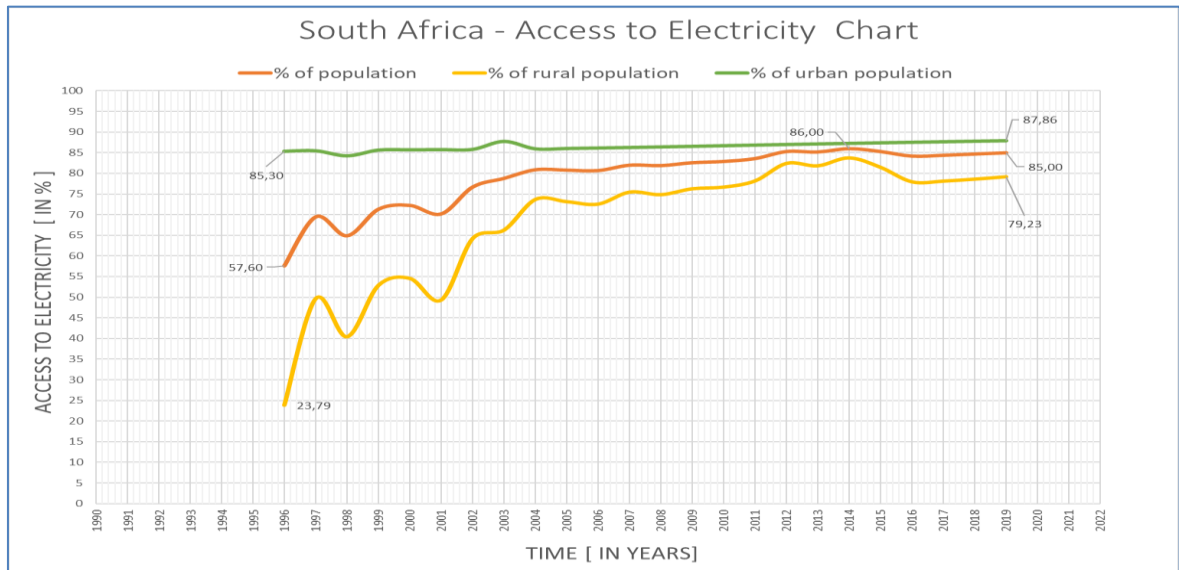


Figure 3: Access to Electricity in South Africa as a % of Population

Sources: <https://data.worldbank.org/>, Eskom and <http://www.energy.gov.za/>

Prior to the end of apartheid in 1993, just 36% of the population had access to electricity as a result of Racial Exclusion (RSA Parliament, 1994). Rural vs Urban population who had access to electricity around 1996 was at 23,8% vs 85,3% respectively (RSA Parliament, 1994). Between 1994 & 2016, ESKOM, under the ANC Government increased access to over 88% of the country's population (INEP, 2022).

Figure 5 below indicates where South Africa is, when compared to the aggregated data of middle-income countries bracket. It can be observed that it is has been in line with them, although since 2011 it has fallen behind and this could be linked to a number of elements, ranging from population increase, the energy insecurity challenges that began in 2007, financial, political and investment challenges the country is facing, but not limited to these, as there could be a number of reasons.

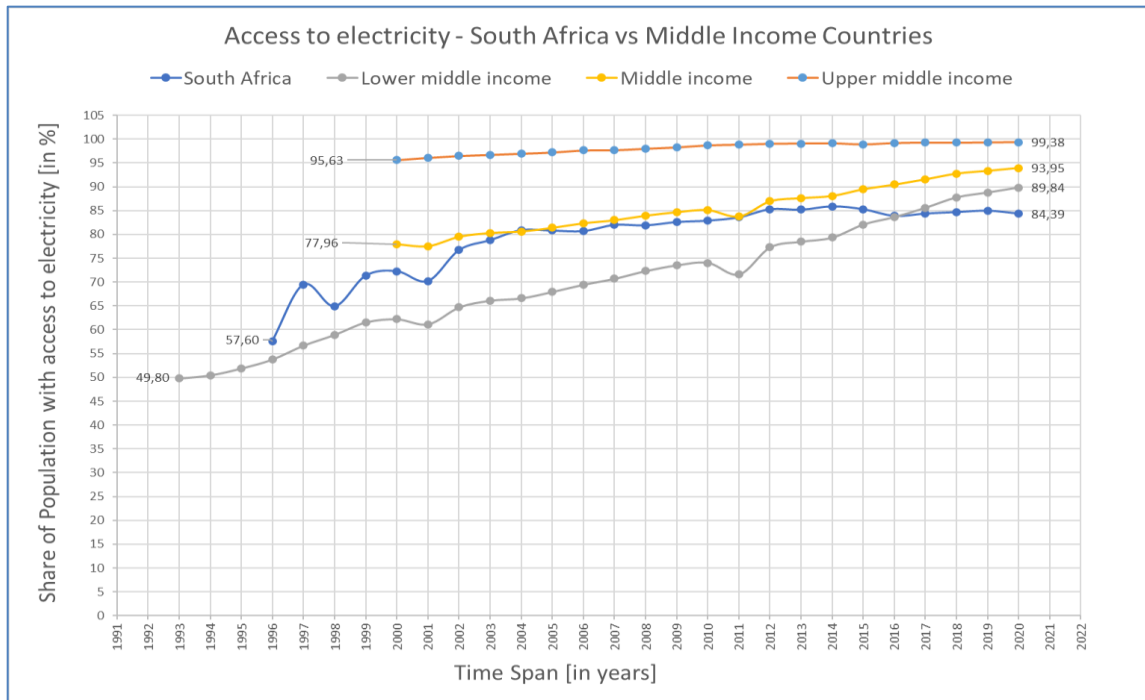


Figure 4: Access to Electricity in South Africa as a % of Population vs middle income countries aggregated data

Sources: <https://data.worldbank.org/indicator/>, <http://www.energy.gov.za/> and <https://www.iea.org/>

4.1.2 South Africa's Electrical Energy Generation Data Analysis

Eskom Holdings SOC (Ltd) is South Africa's national electricity generating, transmitting and distribution company. It is a vertically integrated utility across its operations that serves South Africa and the Southern African Development Community (SADC) area with power.

Utilizing resources from the natural environment, such as coal, nuclear fuel, diesel, as well as water and the wind, Eskom generates more than 90% (205 688 GigaWatt-hours, GWh) of the electricity delivered to a wide variety of clients in South Africa and the surrounding region (Eskom, 2022). It owns and operates many coal-fired, gas-fired, hydroelectric, pumped-storage, and one nuclear power station (Eskom, 2022).

The power generated by Eskom and IPPs, together with imports from neighbouring countries, is delivered in bulk to distributors, i.e., Eskom Distribution, Municipalities,

and big Metropolitans as well as dispersed to industrial, commercial, residential, and other consumers through transmission and distribution networks (Eskom, 2022).

South Africa's electricity production is primarily based on coal, In 2021, coal accounted for 84.4% of electricity production in South Africa (Stats SA,2023), while clean energy sources accounted for 13.7%. In 2022, coal was expected to fall to below 60% of electricity production as Eskom's coal-fired power plants are phased out. Coal is currently the mainstay of the South African energy system, meeting around 70% of installed power generation capacity, and comprises around 80% of the country's energy mix (IEA, 2020). Other sources of electricity generation in South Africa include nuclear power (5%), hydro power (2%), and renewable energy sources such as wind, solar, and biomass (16%) (IEA, 2020). South Africa's total domestic electricity generation capacity is 58,095 megawatts (MW)

In December 2022, electricity generation (production) declined by 8.3% annually. The total amount of power generated in 2022 was 3.9% less than in 2021 (Stats SA, 2023). The yearly power output decline of 3.9% follows increases of 2.0% in 2021 and 5.2% in 2020 (Stats SA, 2023).

Figure 6 below, shows the amount of electricity South Africa generates, and it can be seen that from the 1990s the generation of electricity was increasing, even though there was a slight from 1997, it can be observed that it started increasing again from the year 2001, until it hit the all time high of 263,48 TWh (TeraWatt-hours) in 2007, when actually our electricity loadshedding challenges began, when the generation capacity was first exceeded by the demand. After that highest generation, the decline started and with minor increaments, and more declines continuing to 244,32 TWh in 2021.

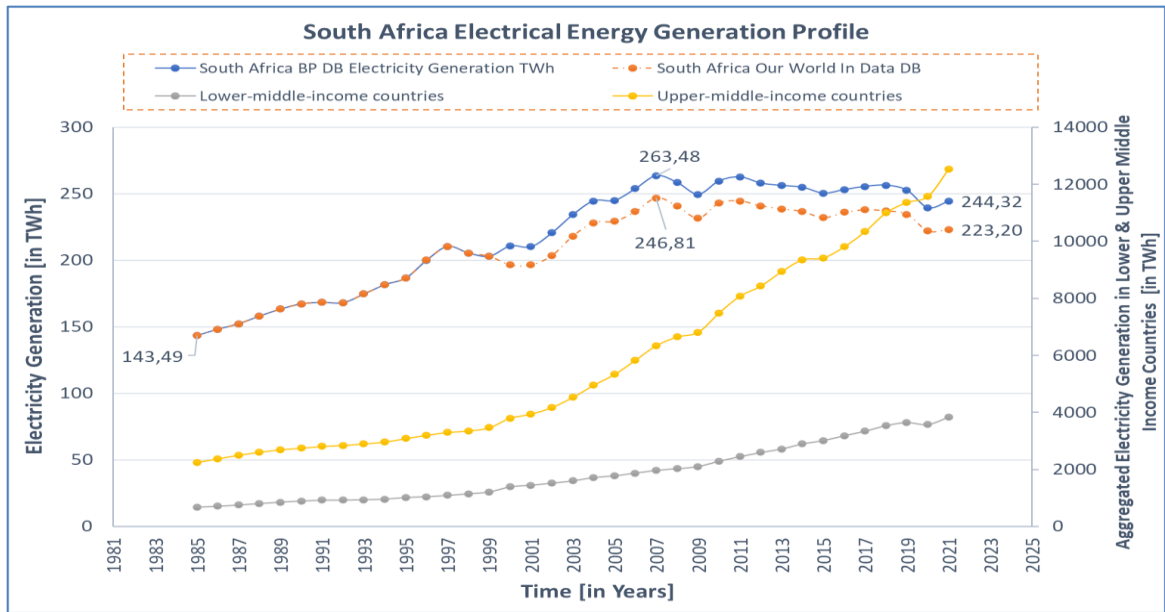


Figure 5: Electricity generation profile of South Africa

Sources: Own analysis based on based on five main sources: [Eskom \(2022\)](#) , [BP Statistical Review of World Energy](#), [Ember Yearly Electricity Data \(2022\)](#), and [Ember European Electricity Review \(2022\)](#), [Our World in Data \(2021\)](#)

It should be noted that the trends for South Africa differ slightly by 7% to 8% from the year 2000, it is unclear why the databases of BP Statistical Review of World Energy and Our World in Data differs. The higher output values have been used for the analysis above as Eskom database also confirmed the higher outputs.

The trends of South Africa as compared with the aggregated values of the lower and upper middle-income countries are increasing prior 2007, but it can be observed that the South African trend start dropping from 2007 till to date, while the cumulative aggregated trends for the whole middle-income countries continue an upward trend, as required, to maintain the security of the electricity energy supply as populations of these countries increases.

Figure 7 below, take this a step further where the electricity generated is looked at from a perspective of each individual in the population. It can be seen that electricity generation per capita has been dropping, since 2007, as expected based on very little additional generation capacity as the population increases, although one expects the decreasing rate should be low.

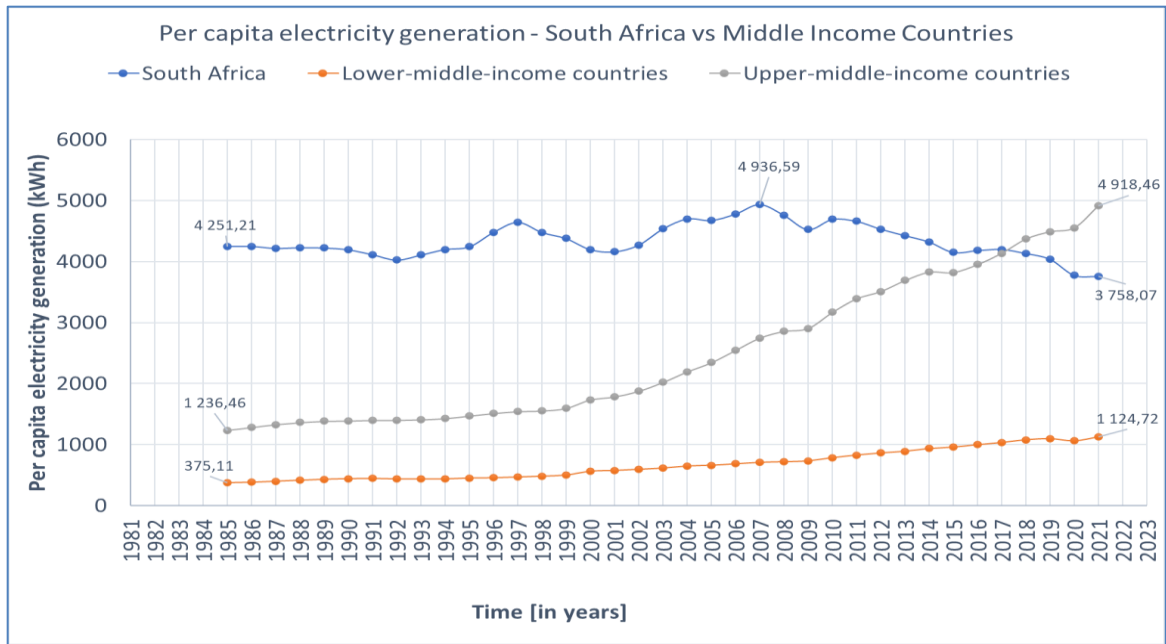


Figure 6: Average Annual Electricity generation profile per capita of South Africa

Sources: Own analysis based on based on five main sources: [Eskom \(2022\)](#) , [BP Statistical Review of World Energy](#), [Ember Yearly Electricity Data \(2022\)](#), and [Ember European Electricity Review \(2022\)](#), [Our World in Data \(2021\)](#)

The highest per capita electricity generation was achieved in 2007 at a value of 4937 kWh and at the end of 2021, it was sitting at 3758 kWh, this is an indication of the energy insecurity challenges that the country is faced with, while the population and demand keeps rising. If the South African trend can be compared with an aggregate of the upper and lower-middle income countries, the declining trend for south Africa is clearly visible.

It can also be observed that the year 2017 was the year where South Africa’s per capita electricity generation started becoming lower than the aggregated of the upper middle-income countries and has been declining continuously.

Figure 8 below indicates the contribution of electricity as a share of primary energy for South Africa, and can be seen to be between 15 to 19%, with the highest share of 18,12% corresponding to the highest levels of electricity generated which is in year 2007.

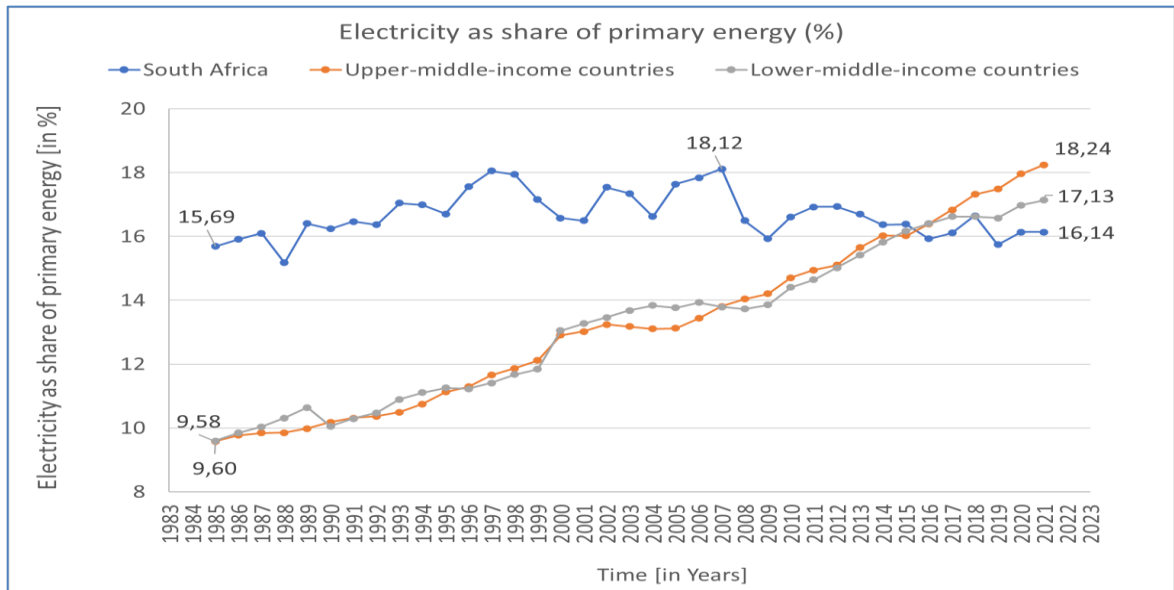


Figure 7: Electricity as a share of Primary Energy Supply

Sources: Own analysis based on based on five main sources: [Eskom \(2022\)](#) , [BP Statistical Review of World Energy](#), [Ember Yearly Electricity Data \(2022\)](#), and [Ember European Electricity Review \(2022\)](#), [Our World in Data \(2021\)](#)

It can also be seen on the Figure 9 above, that since 2007, the share of electricity from the primary energy sources has been declining, inline with the declining average annual electricity generation profile in Figures 6 & 7. Lastly Figure 9 shows the share in percentage of electricity generated by different primary sources available to South Africa. It can be observed that Electricity generation is dominated by Coal, followed by Nuclear. Production from Coal in 1985 was 94,36% and in 2021 it was 86,35% and from Nuclear it was 3,70% in 1985 and 5,44% in 2021.

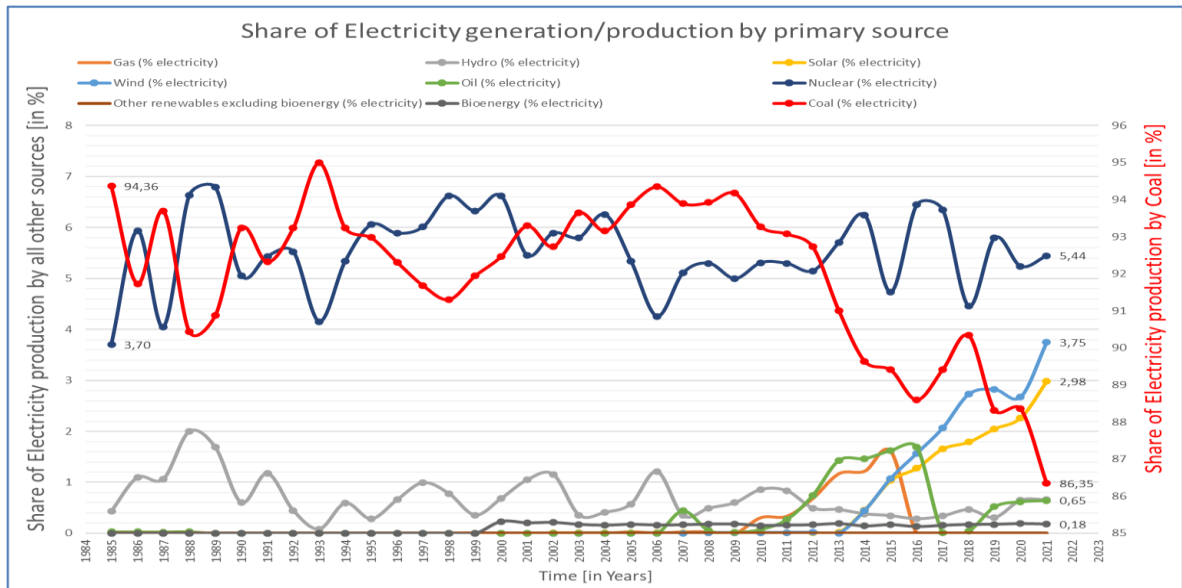


Figure 8: Share of Electricity generation/production by primary source

Sources: Own analysis based on based on five main sources: [Eskom \(2022\)](#) , [BP Statistical Review of World Energy](#), [Ember Yearly Electricity Data \(2022\)](#), and [Ember European Electricity Review \(2022\)](#), [Our World in Data \(2021\)](#)

It is clear from the data that the generated electricity has been declining and this shouldn't be the case, unless ofcourse the demand/consumption has also been declining. Has the demand been declining?

The nation can produce 235 TWh of energy domestically, which is over 113% of its own energy demands (World Data Info, n.d.). South Africa uses coal, natural gas, oil, and renewables such as hydroelectricity and solar power as energy sources (Our World in Data, n.d.).

4.1.3 South Africa's Electrical Energy Consumption Data Analysis

Since the early 1990s, South Africa's power usage has climbed dramatically (Inglesi-Lotz & Blignaut, 2011). In 2021, the South African average per capita power usage was around 3,688 kWh, which was about 10 times the average consumption of the Sub-Sharan Afraica (Enerdata, n.d.). This was down from 3,949 KWh per capita in 2019, as reported by the World Bank (n.d.). The peak was in 2007 for both the total consumption (243 TWh) and the per capita consumption (4873 kWh).

In December 2022, the distribution (consumption) of electricity declined by 7.6% annually. In 2022, total power distribution was 2.8% less than in 2021. The yearly decline in power distribution of 2.8% follows increases of 2.3% in 2021 and 5.0% in 2020.

According to Figure 10, below the country's consumption of 219,06 TWh occurred in 2021, where renewable energy was comprising 10.5% of real consumption (World Data Info, n.d.). Electricity demand is the sum of total electricity generation and imports and exports of electricity.

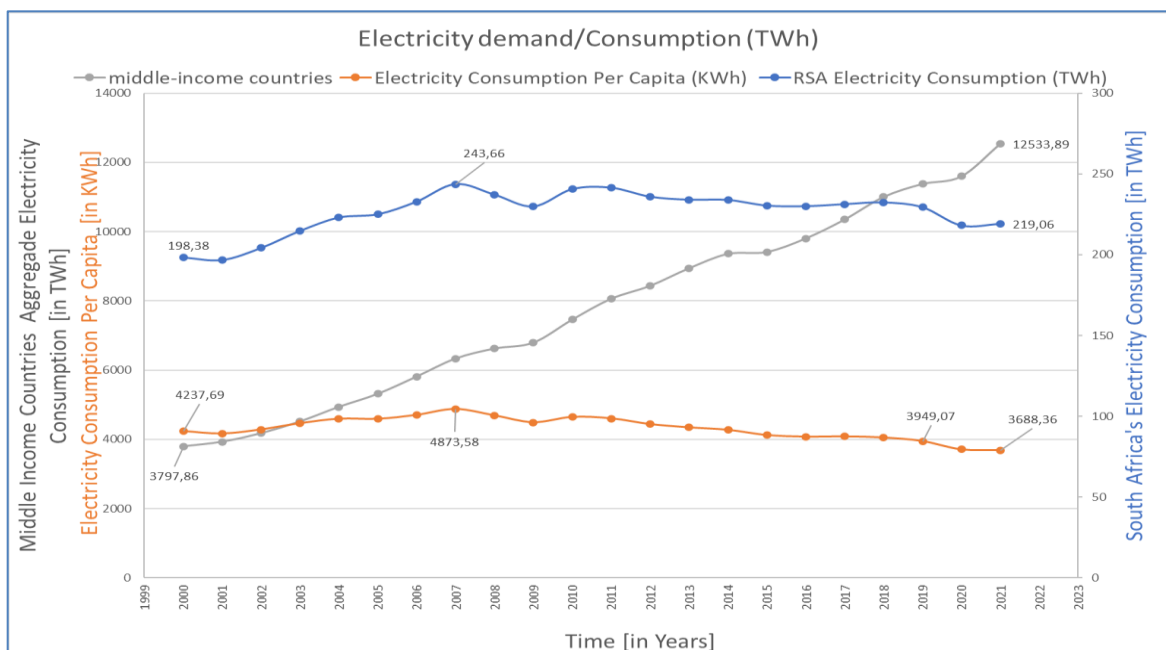


Figure 9: Electricity Total & Per Capita Consumption in South Africa vs Middle-Income Countries

Sources: Own analysis based on based on five main sources: [Eskom \(2022\)](#) , [BP Statistical Review of World Energy](#), [Ember Yearly Electricity Data \(2022\)](#), and [Ember European Electricity Review \(2022\)](#), [Our World in Data \(2021\)](#) , World Bank Open Data, (n.d.)

The industrial sector is the largest consumer of electricity in South Africa, consuming up to 52% of electricity consumption (Enerdata, n.d.) in 2021. This is preceded by the residential (20%) and commercial services (15%) sectors and 13% Others (Enerdata, n.d.). In 2021, petroleum products contributed for 6% of the sector's overall energy consumption.

The International Energy Agency (IEA) forecasts that South Africa's power final energy consumption would rise from 2018 to 2040 under all scenarios (IEA, 2022). Under the Stated Policies Scenario, the final energy consumption of electricity is anticipated to rise from 441 TWh in 2018 to 436 TWh in 2040 (IEA, 2022).

4.1.4 South Africa's Economic Data Analysis

4.1.4.1 South Africa's GDP and Inflation rate Analysis

The South African economy has underperformed over the previous decade, with a lower GDP (Gross Domestic Product) per capita in 2019 than it was in 2008 (OECD, 2022). Approximately over 35% unemployment persists as a high rate (OECD, 2022). In the twenty years since 1994 to 2014, South Africa has had exceptional economic growth (Coleman, 2014), transforming from an apartheid state to a country with an upper-middle income (Coleman, 2014).

The GDP of South Africa increased by 1.6% in the 3rd quarter of 2022, following a 0.7% decline in the 2nd quarter (Stats SA, 2022).

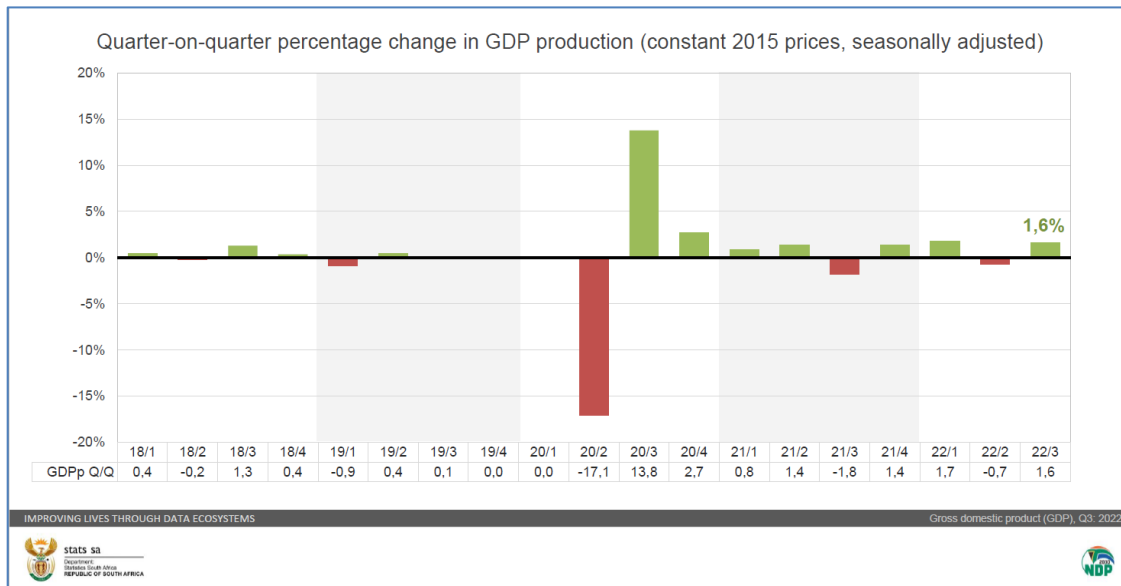


Figure 10: GDP in Quarter-on-Quarter % change 2018 to 2022

Source: Stats SA.

[https://www.statssa.gov.za/publications/P0441/GDP%202022%20Q3%20\(Media%20presentation\).pdf](https://www.statssa.gov.za/publications/P0441/GDP%202022%20Q3%20(Media%20presentation).pdf)

Not only does the 1.6% increase in the third quarter return the economy to pre-pandemic levels, but the quarterly real GDP now stands at the highest it has ever been, surpassing the previous top of R1,152 billion established in the 4th quarter of 2018 (Stats SA, 2022). Eight of the 10 industries' economic production increased in the 3rd quarter of 2022 (Stats SA, 2022). Agriculture, forestry, and fishing increased by 19.2%, the most positive contribution. This was mostly due to an increase in the output of agricultural production and horticultural goods (Stats SA, 2022).

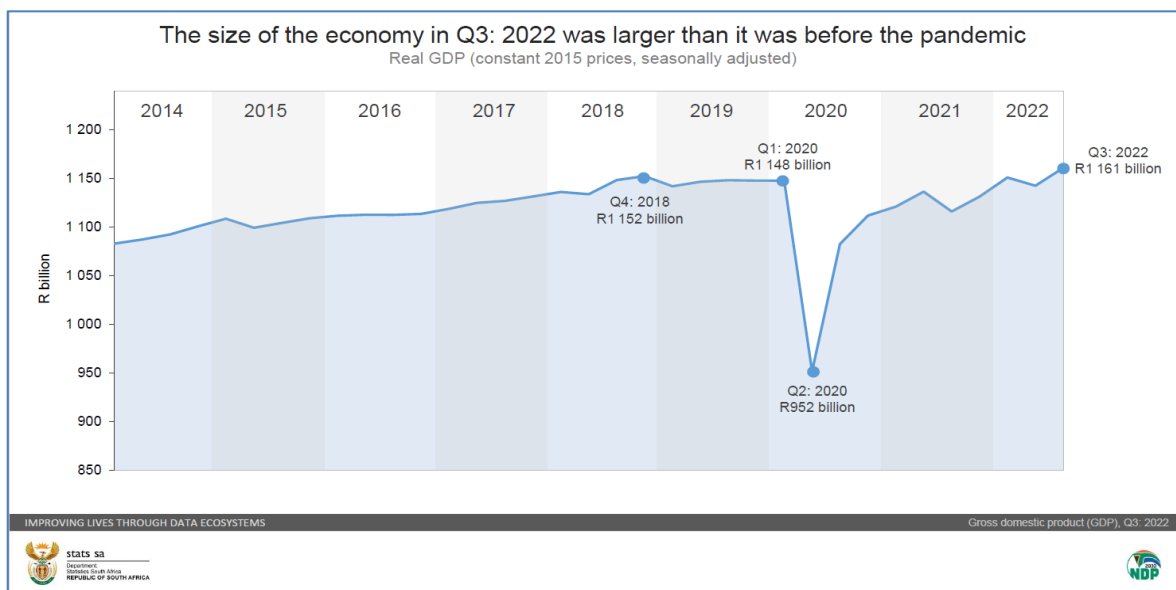


Figure 11: Real GDP (constant 2015 prices) Economic Recovery from COVID-19
Source: Stats SA.

[https://www.statssa.gov.za/publications/P0441/GDP%202022%20Q3%20\(Media%20presentation\).pdf](https://www.statssa.gov.za/publications/P0441/GDP%202022%20Q3%20(Media%20presentation).pdf)

The epidemic impeded economic expansion for almost two years. In the 1st quarter of 2022, real GDP surpassed pre-pandemic levels (Figure 11). The economy contracted by 0.7% in the 2nd quarter, mostly as a result of significant floods in KwaZulu-Natal.

South African rate of GDP growth has averaged 0.62% from 1993 to 2022, hitting a peak of 13.8% in the 3rd quarter of 2020 (Trading Economics, n.d.). Private consumption and investment are anticipated to continue to be the primary growth

drivers, with the GDP growing 1.7%, 1.1%, and 1.6% in 2022, 2023, and 2024, respectively (OECD, 2022).

Over the previous two decades, South Africa's inflation rate has ranged between 0.7% and 18.7%. The inflation rate in 2020 was 3.28%, in 2019 it was 4.12 %, and in 2018 it was 4.6% (Stats SA,2022). The average annual rate of inflation for 2022 was 6.9%, up from 4.5% in 2021 (Stats SA,2022).

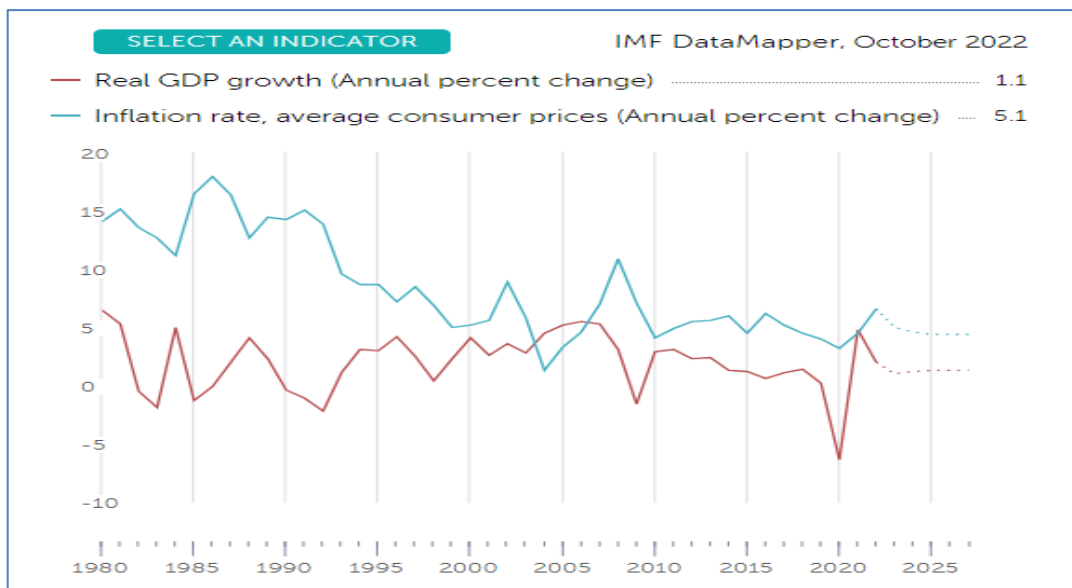


Figure 12: South Africa’s Real GDP vs Inflation rate

Source: International Monetary Fund (IMF), <https://www.imf.org/en/Countries/ZAF>

Deloitte predicts that South Africans have lost GDP due to power outages (energy insecurity) until October 2022 (Marais & Jinabhai, 2022). Under the baseline scenario, the South African rand is expected to average R16.90/\$ this year (PwC, n.d.), while the IMF forecasts a real GDP growth of 1.2% for 2023 (IMF, 2023). The World Bank predicts that Sub-Saharan Africa's economic growth would decrease from 4.1% in 2021 to 3.3% in 2022 due to a slowing global economy and increasing inflation (World Bank, 2022).

4.1.4.2 South Africa's Unemployment Rate Data Analysis

According to Statista, South Africa's unemployment rate peaked at 33.56% in 2021 (Statista, 2022). According to Bloomberg, South Africa's rate of unemployment is one of the highest in the world, with an enlarged definition of 43.1% (Bloomberg, 2022).

According to Trading Economics, South Africa's rate of unemployment in the second quarter of 2022 was 33.9% (Trading Economics, 2022), whereas Macrotrends claims it was 28.46% in 2019 (Macrotrends, 2020). In the 1st quarter of 2022, according to Statistics South Africa, the rate of unemployment for individuals aged 15 to 24 was 63.9% (Stats SA, 2022a). The increased definition of unemployment among 15–34-year-olds was 50.4%. (Stats SA, 2022a).

The Figures 14, and 15 depicts graphically the South African unemployment rate from two different sources.

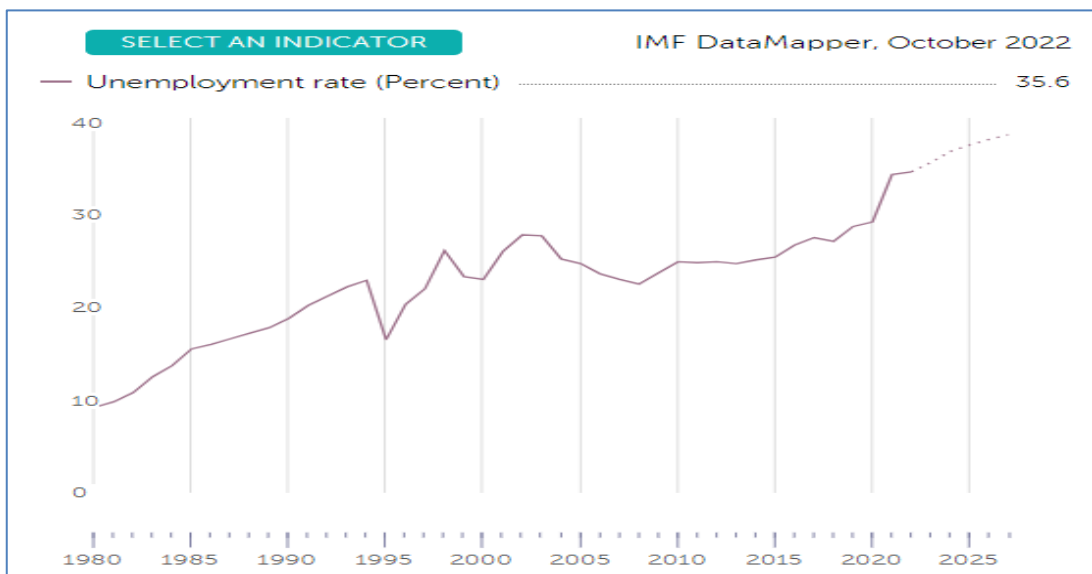


Figure 13: RSA unemployment rate 1980 to 2022, with prediction to 2026

Source: IMF (2022)

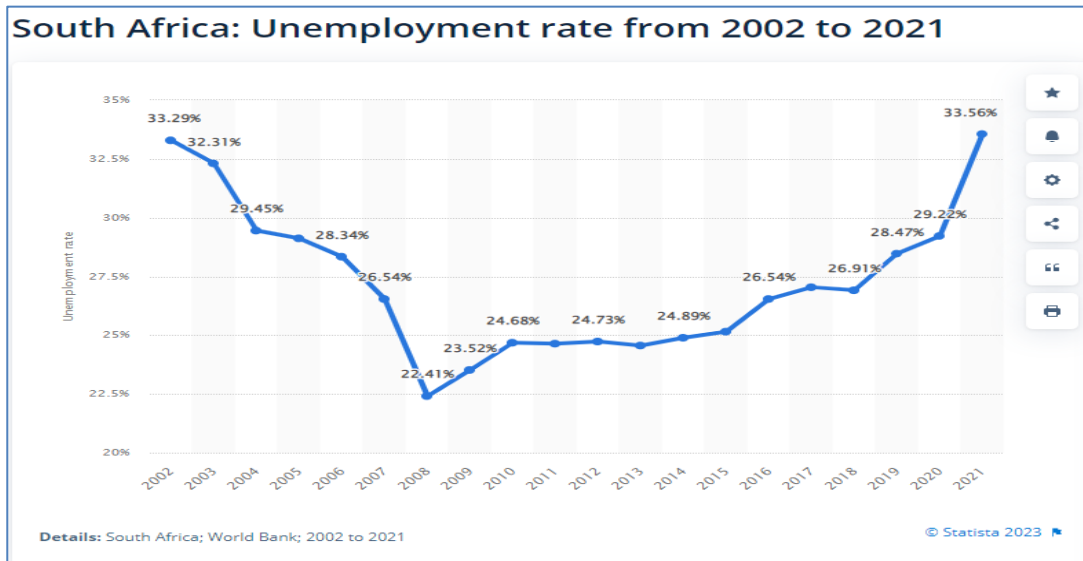


Figure 14: RSA unemployment rate 2022 to 2021

Source: World Bank, and Statista (2022).

Millions of people have lost their employment due to the COVID-19 epidemic, whereas the number of discouraged workers has skyrocketed (OECE, 2022). Prior to the crisis, investment was already declining due to policy instability and a lack of vital infrastructure (OECE, 2022). Multiple regulatory constraints pose a danger to the recovery (OECE, 2022). To set the government borrowing trajectories on a sustainable route and to finance significant unmet requirements in education, health, and social expenditures, stronger growth is required.

The high unemployment rates in South Africa, especially among young people, are quite concerning. The South African government has launched several measures and programmes in an effort to lower the country's high unemployment rate, although these have not yet been wholly effective (Bloomberg, 2022).

4.1.5 South Africa’s Social Data Analysis

4.1.5.1 Population and Annual change Data Analysis

The predicted South Africa's population in 2021 was 60,14 million (Stats SA, 2021) with an annual growth rate of 1.28 percent (Stats SA, 2021). This is a 2.278% growth from 2020.

In South Africa, population growth is anticipated to continue, but at a slightly slower pace than in the preceding century, with the annual growth rate falling below 1% by 2023 (Stats SA, 2021).

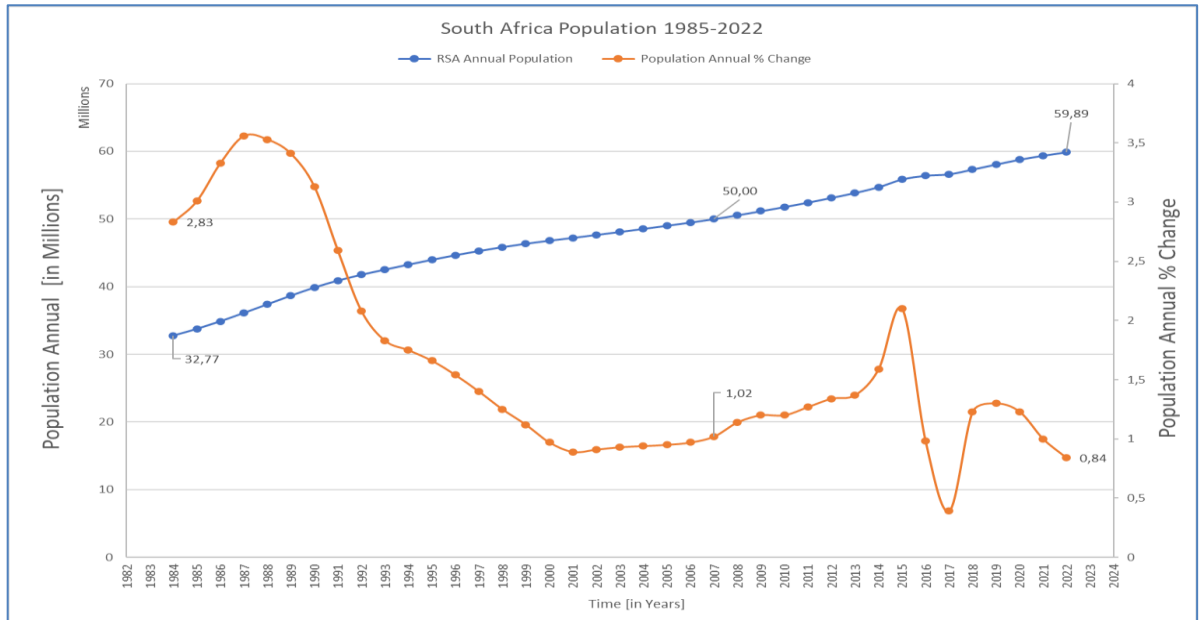


Figure 15: RSA population vs population annual change 1984 to 2021

Source: World Bank, and Our World In Data (2022).

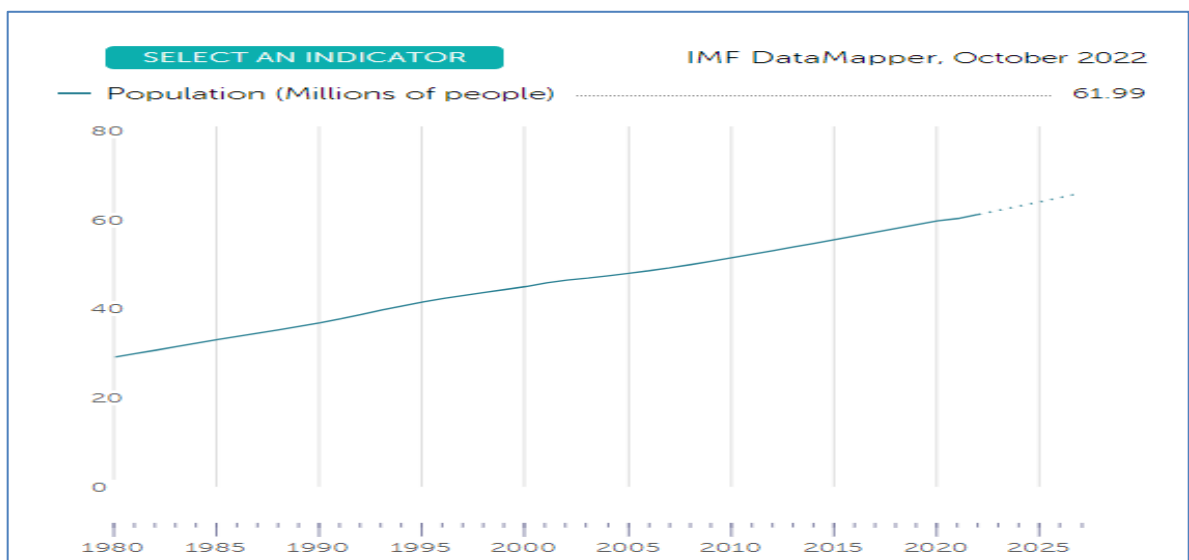


Figure 16: RSA population 1980 to 2022 and projection to 2027

Source: IFM (2022).

Between 2022 and 2027, the overall population is projected to increase by 4,8 million people (+7.86%) (Stats SA, 2021), but the population growth is projected to decline by more than half to 0.3% (Stats SA, 2021).

4.1.5.2 South Africa's Poverty Data Analysis

According to the World Bank, (n.d.) in 2018, the South African poverty threshold at national poverty limits was 56.9%, In 2019, the proportion was 55.5%, while in 2020, it was 54.7%. In 2021, the adult poverty headcount rate was 46.1% for men and 52.0% for females, and it is anticipated to reach 54.7% by 2022 (world bank, 2022).

The level of poverty in South Africa has been decreasing over the past few years. This can be attributed to the government's efforts to address issues such as limited access to essential services, and food insecurity. These policies have resulted in an increase in household incomes and improved access to basic services. The poverty rate is expected to decrease further in the coming years as more government initiatives are implemented. Although the biggest issue of unemployment remains and is accelerating the poverty levels.

4.1.6 South Africa's Environment Data Analysis

South Africa was ranked the world's 14th largest emitter of greenhouse gases (GHGs) (Carbon Brief,2018). Its CO₂ emissions are mainly due to burning fossil fuels (Coal) for energy production and industrial activities (Carbon Brief,2018). In 2021, South Africa emitted 435 million metric tons of carbon dioxide (MtCO₂) emissions from fossil fuel combustion and industrial purposes (Statista, 2023). Per capita, South Africa's CO₂ emissions are equivalent to 6.95 tons per person (Statista, 2023).

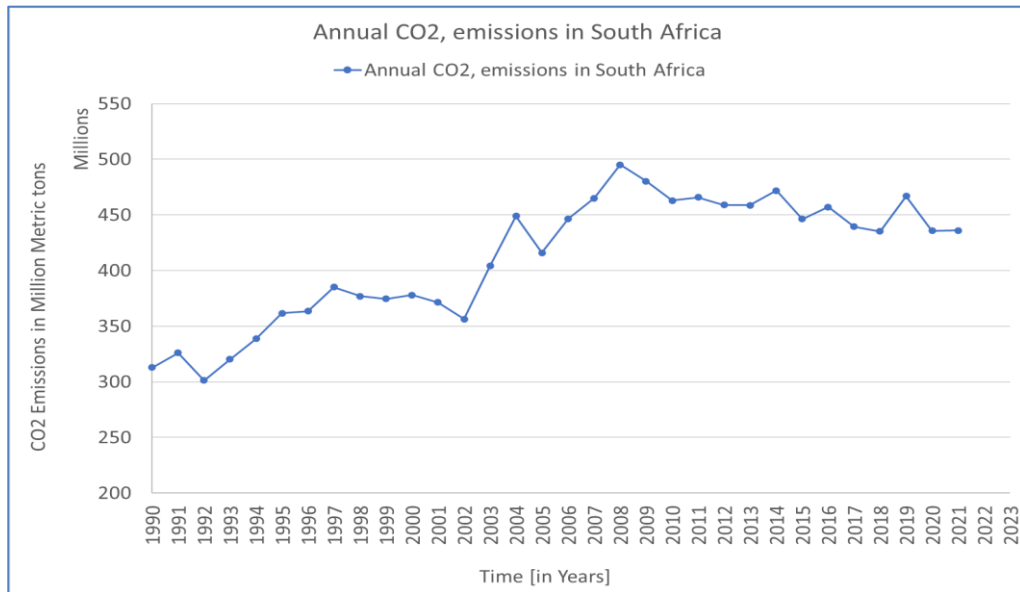


Figure 17: RSA Carbon dioxide (CO₂) emissions from fossil fuels and industry
 Source: Our World in Data, (n.d), <https://ourworldindata.org/co2/country/south-africa>

South Africa has taken steps to address climate change, including policy frameworks relating to climate change adaptation, data monitoring and surveillance of climate change, cutting carbon emissions and promoting resilience to climate change (World Bank Climate Change Knowledge Portal, 2020; Climate Watch, 2019), as well as considering the impact of climate change in court cases such as EarthLife Africa Johannesburg v Minister of Environmental Affairs and Others (van der Bank, Karsten, 2020).

Climate change in South Africa is expected to raise temperatures by 2-4 degrees Celsius by the end of the century (van der Bank, Karsten, 2020), leading to increased water scarcity, pest infestations, droughts and floods (Climate Watch, 2019). It could also lead to thousands of species becoming extinct and have negative impacts on health, human settlements and food insecurity (World Bank Climate Change Knowledge Portal, 2020).

4.1.7 South Africa's Political Data Analysis

South Africa's political landscape plays a significant role in shaping energy security and addressing energy insecurity challenges. Based on the above data from different sources, a political landscape can be summarized.

The energy insecurity in South Africa, characterized by fluctuations in electricity access, generation, and consumption, has several political implications. The heavy reliance on coal-fired power plants contributes to environmental concerns and potential climate change impacts. The lack of diversification in energy sources hampers the country's transition to cleaner and more sustainable energy options. The declining electricity generation per capita indicates challenges in meeting the growing energy demands of the population.

These energy insecurity issues can have social and economic consequences, including income inequality and limited access to reliable electricity for certain communities. The reliance on coal also poses challenges for reducing carbon emissions and addressing climate change commitments.

To mitigate energy insecurity, South Africa needs to diversify its energy mix, promote renewable energy sources, improve energy efficiency, and invest in infrastructure and technology for a more reliable and sustainable energy system. This would require policy reforms, investment incentives, and international cooperation.

1. **Energy Policy and Governance:** South Africa's energy sector is highly influenced by political decisions, policies, and regulations. The government's energy policies, such as the Integrated Resource Plan (IRP), National Energy Efficiency Strategy, and Renewable Energy Independent Power Producer Procurement Program (REIPPPP), have a direct impact on the country's energy mix, energy access, and energy security.
2. **Energy Infrastructure Development:** The government's role in infrastructure development is crucial for ensuring energy security. In South Africa, major energy infrastructure projects, such as the construction of power plants,

transmission lines, and renewable energy installations, require political support, regulatory frameworks, and financial investment. Political stability and policy consistency are essential for attracting private investments and driving infrastructure development.

3. **State-Owned Enterprises (SOEs):** South Africa's energy sector is closely linked to state-owned enterprises such as Eskom (electricity generation and transmission) and PetroSA (oil and gas). These entities are responsible for providing essential energy services to the country. However, political interference, mismanagement, and governance challenges within SOEs have sometimes resulted in energy supply disruptions and inefficiencies, contributing to energy insecurity.
4. **Socio-Political Factors:** Energy insecurity in South Africa is often intertwined with socio-political challenges, including income inequality, unemployment, and access to basic services. Political decisions and policies aimed at addressing these issues, such as social grants, job creation initiatives, and rural electrification programs, can have a significant impact on energy access and the overall energy security situation.
5. **International Relations and Energy Cooperation:** South Africa's energy security is also influenced by its international relations and energy cooperation. Political engagements with neighboring countries, international organizations, and energy partners shape cross-border energy trade, energy investments, and regional energy integration efforts. Collaborative initiatives, such as the Southern African Power Pool (SAPP), aim to enhance energy security and access in the region.

4.2 Conclusion

The data and study shows that prior to the end of apartheid in 1993, just 36% of the population had access to electricity as a result of Racial Exclusion. In 2020, 84.39% of the population in South Africa had access to electricity, a 0.61% decline from 2019 and 0.3% increase from 2018. In 2021, coal accounted for 84.4% of electricity production in South Africa, while clean energy sources accounted for 13.7%. Other sources of electricity generation in South Africa include nuclear power (5%), hydro power (2%), and renewable energy sources such as wind, solar, and biomass (16%). South Africa's total domestic electricity generation capacity is 58,095 megawatts (MW).

The industrial sector is the largest consumer of electricity in South Africa, consuming up to 52% of electricity consumption in 2021.

The study also shows that electricity generation per capita has been dropping since 2007, when the energy insecurity challenges began. The highest per capita electricity generation was achieved in 2007 at a value of 4937 kWh and at the end of 2021, it was sitting at 3758 kWh. The share of electricity from the primary energy sources has been declining since 2007, and coal is currently the mainstay of the South African energy system, meeting around 70% of installed power generation capacity, and comprises around 80% of the country's energy mix.

The South African economy has underperformed over the previous decade, with a lower GDP (Gross Domestic Product) per capita in 2019 than it was in 2008.

CHAPTER 5: DISCUSSIONS OF RESULTS AND OBSERVATIONS.

5.1 Introduction

The previous chapter covered the data analysis used for the study. This chapter will cover the discussions of the results, observations, and findings from the secondary data, the economic and social impacts of energy insecurity in South Africa, which will assist in answering research questions and recommending the potential solutions to address the issue and proposed energy mix policy solution.

5.2 Discussion on Electricity Access, and Socio-Economic & Environmental impact

Access to electricity is critical for economic growth and development in South Africa (Sarkodie, Adams, 2020). Increasing levels of growth in income improve access to electricity, which can contribute to job creation and economic growth (Ndlovu, 2013).

Access to power catalyses economic development in rural areas and creates more jobs and new industries (World Bank, 2020). Without reliable access to energy, it poses a key barrier to economic development in emerging economies (World Bank, 2020). When electricity access to the population is increased, it needs to be balanced with additional generation capacity to cater for the additional load being added to the grid.

Access to abundant, affordable, secure, safe, and clean energy is beneficial for societies, but energy extraction and processing always involve some forms of environmental disruption, including air pollution, climate change, water pollution, thermal pollution, land degradation, and more (Stern, 2004). Renewable energy sources can reduce the environmental impact of energy systems (Kumar, 2020), but they also come with their own set of social and economic impacts (Kumar, 2020).

The limitations of lack of access to electricity includes but is not limited to impeded businesses and no job creation and growth which negatively affects societies. Access to energy is essential for security, climate change, food production, and strengthening economies while protecting ecosystems (Energy Education, n.d.). A question that may arise may be whether there is a means to give electricity access that enriches everyone equally?

There are several ways to make access to electricity more equitable for everyone. This includes implementing progressive pricing structures, expanding grid access to underserved and marginalized communities, investing in renewable energy sources that can be locally owned and operated, providing education and training programs, and implementing policies to support energy efficiency and conservation.

Achieving equitable access to electricity will require a combination of policy, technical, and social solutions that are tailored to the specific needs and contexts of different communities.

5.3 Discussion Energy Generation, Consumption and Socio-Economic & Environmental impact

Eskom, the state-owned power utility in South Africa, has been facing a number of challenges that have contributed to the country's energy insecurity problem that affects social, environmental, and economic aspects of the country.

Electricity generation and consumption in South Africa has declined due to a variety of factors, including aging infrastructure, lack of maintenance and investment, and a lack of new power generation projects (PSA, 2015). The situation has been exacerbated by the ongoing financial and operational problems at Eskom (PSA, 2015), leading to a decrease in economic development and growth (ITA, 2021). The lack of investment in this area has led to frequent power outages and a lack of reliability in the power supply, which has a negative impact on businesses, households, and the economy as a whole.

There is a strong relationship between energy availability and economic growth, and studies have established the relationship between energy consumption and economic growth according to the energy Kuznets curve (Dai et al., 2022), while others have found that developing countries heavily rely on electricity consumption for economic growth regardless of oil prices (Koščak Kolin et al., 2021) and that access to energy is necessary for growth. Additionally, the centuries-old linkage between economic growth and primary energy demand is beginning to decouple (Sarkodie & Adams, 2020), while energy abundance can also be a limiting factor or essential input to growth.

There is a strong positive correlation between energy availability and GDP growth (Burke et al., 2018) (Dai et al., 2022). Studies have found that energy use and GDP are positively correlated, although energy intensity has declined over time and is usually lower in richer countries (Stern, 2018). Additionally, higher levels of GDP are correlated with greater electricity use, access, and consumption (Burke et al., 2018), while energy conservation measures may negatively affect economic growth (Asghar, 2008).

Energy infrastructure can also contribute to economic development in several ways, such as serving as a key factor of production (Burke et al., 2018). Additionally, research suggests that there is a causal relationship between energy consumption and economic growth ((Zhixin & Xin, 2011).

In recent years, the government has been pursuing an energy mix strategy, including the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) to boost the power generation capacity, and also to reduce the dependency on Eskom. This strategy aims to diversify the energy mix by adding more renewable energy sources to the grid, which is expected to increase the reliability of the power supply and reduce the cost of electricity.

Eskom's power generation is heavily dependent on coal, which is a major source of greenhouse gas emissions and contributes to air pollution, this has led to a climate change environmental impact.

To restore investor confidence and rebuild economic development and growth, the South African government will need to take a number of steps. These include investing in new power generation projects, such as Nuclear, renewable energy sources such as solar and wind, as well as upgrading and maintaining existing infrastructure. Additionally, the government will need to address the financial and operational issues at Eskom and implement measures to improve the efficiency and reliability of the power grid.

Another important step that the government can take is to implement policies that encourage private sector investment in the energy sector, such as tax incentives and regulatory reform.

5.4 Discussion Stakeholder Theory

To address energy insecurity and improve future energy security in South Africa, effective decision-making requires collective collaboration among these stakeholders. They need to come together to examine the challenges, identify shared goals, and develop strategies that prioritize meeting the nation's energy security needs. The focus should extend beyond decarbonization and consider the diverse needs of stakeholders involved in energy policy and implementation (Aly, et. al., 2019)

Research Question 1: What has been the economic, social, political, and environmental impact of energy insecurity in South Africa?

Based on the stakeholder theory and the analysis of the South African energy sector stakeholders, it is evident that energy insecurity in South Africa has had severe and detrimental economic developmental impacts. The country has faced a wide range of social, economic, political, and environmental challenges as a result of this wicked problem.

The energy insecurity has hindered economic growth, impeded investment, and affected various industries reliant on a stable energy supply. It has also exacerbated social inequalities, as access to reliable and affordable energy becomes limited, impacting vulnerable communities. Furthermore, the political landscape is

influenced by the need to address energy insecurity, requiring policymakers to navigate complex trade-offs and find sustainable solutions. Additionally, energy insecurity has contributed to environmental concerns, as the reliance on fossil fuels and lack of diversification hinder progress towards decarbonization and sustainable energy sources. Addressing these multifaceted impacts requires a careful examination of the problem and intervention through collaborative efforts among multiple stakeholders.

Research Question 2: What strategies can be used and implemented to improve and mitigate further energy insecurity in the future of South Africa?

To effectively address energy insecurity and ensure a secure energy supply for South Africa's economic development, it is essential to engage in effective decision-making through collective collaboration among different stakeholders. This collaborative approach should involve government officials, energy industry experts, and representatives from economic, social, political, and environmental sectors who are involved in energy policy and implementation strategies.

By expanding the focus beyond decarbonization and prioritizing meeting the nation's energy security needs, stakeholders can work together to develop comprehensive strategies. These strategies should consider diversifying the energy mix, increasing renewable energy penetration, enhancing energy efficiency measures, and promoting technological innovations.

Additionally, stakeholder collaboration should include the identification of potential barriers, trade-offs, and conflicts of interest to ensure sustainable and inclusive decision-making processes. The involvement of stakeholders from various sectors will contribute to a more holistic understanding of the energy insecurity challenge and enable the development of effective strategies to mitigate further energy insecurity in the future.

5.5 Discussions on the research questions

5.5.1 Discussion on why energy insecurity is a wicked problem in South Africa

Energy insecurity in South Africa is often intertwined with other wicked problems such as poverty, inequality, and environmental degradation. One major aspect of energy insecurity is access to affordable and reliable energy sources, particularly in developing countries (World Bank, 2020), which requires policy support and a massive mobilization of public and private capital (World Bank, 2020).

Some of the key factors contributing to energy insecurity in South Africa include:

1. **Limited access to electricity:** Many communities in South Africa still lack access to reliable electricity, which can negatively impact economic development and quality of life.
2. **Dependence on coal:** South Africa has a heavy dependence on coal for electricity generation, which has contributed to air pollution and climate change.
3. **Aging infrastructure:** The country's power grid is aging and in need of upgrading, which has led to power outages and reliability issues.
4. **Political and economic instability:** The country has a history of political and economic instability, which has made it difficult for the government to make long-term investments in energy infrastructure.
5. **Lack of clear policy:** The lack of a clear energy policy has made it difficult for the government to make decisions about how to invest in and develop its energy resources.

All these factors combined make it difficult to find a solution for energy insecurity in South Africa. This can have a significant impact on poverty and inequality, as access to energy is often a prerequisite for economic development and social mobility. Additionally, energy insecurity can also contribute to environmental degradation and climate change, as a lack of access to clean energy sources can lead to increased dependence on fossil fuels and other pollutants.

5.5.2 What has been the economic and social impact of the energy insecurity in South Africa

The economic and social impact of energy insecurity in South Africa has been significant. The country has been facing a power crisis for several years, and it has gotten worse in the past 2 years, characterized by frequent blackouts, known as “loadshedding”. This has had a detrimental effect on the economy, causing businesses to shut down and leading to job losses. The power cuts have led to disruptions in manufacturing and other industries, resulting in lost production and revenue.

Businesses have also had to invest in backup generators and other measures to mitigate the effects of the power outages. Additionally, the energy insecurity has led to higher electricity prices, which has placed a burden on households and further contributed to the country's economic challenges.

The energy insecurity has also had a negative impact on the delivery of basic services such as healthcare and education, and has affected the overall quality of life for many South Africans. The energy crisis has also had a negative impact on the country's infrastructure and industries, particularly mining and manufacturing.

On the social front, energy insecurity has led to increased poverty and inequality, as well as reduced access to basic services such as healthcare and education. It has also had a negative impact on the living standards of many South Africans, especially those in rural areas and low-income households. The crisis has also been a major source of frustration and dissatisfaction among the population, leading to social unrest and protests.

Additionally, the energy insecurity has led to increased dependence on fossil fuels, which has contributed to environmental degradation and increased carbon emission.

5.5.3 What can be done to improve or mitigate further energy insecurity going into the future of South Africa?

To address energy insecurity and its associated wicked problems, a holistic and multi-disciplinary approach is needed. It will also involve tackling the underlying

social and economic issues that contribute to energy insecurity, such as poverty, inequality, and lack of access to education and healthcare.

Governments, private sectors, and international organizations have to work together to identify the root causes of energy insecurity and develop comprehensive solutions that address these issues. This requires cooperation, coordination, and collaboration among different sectors, stakeholders, and levels of government. There are several steps that can be taken to improve or mitigate further energy insecurity in South Africa going into the future. Some potential solutions include:

1. **Diversifying the energy mix:** Increasing the proportion of renewable energy sources such as solar and wind power in the overall energy mix can help to reduce dependence on fossil fuels and improve energy security.
2. **Improving energy efficiency:** Implementing policies and programs to increase energy efficiency in buildings, industries, and transportation can help to reduce energy demand and improve energy security.
3. **Investing in energy storage:** Developing and deploying energy storage technologies such as batteries can help to smooth out fluctuations in renewable energy generation and improve energy security.
4. **Upgrading infrastructure:** Investing in upgrading and maintaining the existing energy infrastructure can help to improve reliability and reduce the risk of power outages.
5. **Increasing interconnection:** Building more interconnections between different regions and countries can help to improve energy security by providing access to a larger pool of energy resources.
6. **Encourage private investment:** The government can also encourage private investment in the energy sector by providing incentives and creating a stable regulatory environment.
7. **Encourage energy conservation:** The government can encourage people to conserve energy by providing information and education about energy conservation, and by implementing pricing structures that encourage conservation.

It is important to note that implementing these solutions will require significant investment, political will and collaboration between government, private sector and civil society.

5.6 Discussion Energy Security

Energy security is a target that all, nations, governments, and businesses globally are striving to guarantee that their economies and operations continue to run smoothly and that their country's populations enjoy access to energy that is economical in cost, reliable, sustainable, and green or renewable energy (Ayoo, 2020). Energy security is an urgent matter to be prioritised due to the fact that the energy requirements in South Africa, and also globally is expanding fast due to population increases, vigorous economic expansion, novel applications of energy which adds to the demand increase, and income growths; however, the energy resources necessary to meet these requirements are, limited and, the ones that can almost guarantee energy security are non-renewable (Alemzero et al, 2021). This has resulted in a situation in which the energy demand is growing faster than the supplies of energy resources available to meet that demand. In addition, the energy production, delivery/transportation, and energy usage by households, industries for production and commercial businesses are key contributors to the emission of greenhouse gases, which in turn cause changes in climate and global warming (Ayoo, 2020).

Energy security, according to the International Energy Agency (1974), is "the uninterrupted availability of energy sources at an affordable price". Accordingly, nations like South Africa that have intermittent energy insecure supplies or are unable to afford to provide a secure energy supply system are said to suffer energy insecurity or instability. Numerous issues that are social, economic, environmental, or a mix of the three, have been seen to result from this.

5.7 Discussion on the impact of the energy insecurity the country at large

Energy insecurity in South Africa has had and will continue to have significant negative impacts on businesses, small to medium enterprises, society, and investments in the country. Power outages and supply shortages can disrupt operations and lead to lost productivity and revenue. This can be particularly devastating for small businesses, which may not have the resources to withstand prolonged periods of disruption.

The impact of energy insecurity has and is also being felt by society, as it has and will continue to lead to increased poverty and unemployment. Business closures and job losses can lead to economic hardship for individuals and families, exacerbating existing poverty and inequality.

Investments in the country has also been negatively affected by the energy insecurity. Businesses and investors may be hesitant to invest in a country with unreliable energy supplies, leading to a lack of growth and development.

In general, energy insecurity can have far-reaching consequences for South Africa, affecting not only the economy and businesses, but also the well-being of individuals and communities.

The Covid-19 global epidemic has highlighted the importance of electricity in many aspects of life, such as ensuring medical equipment is functioning properly in hospitals and that information technology networks are accessible for remote communication and working. A power outage that lasts for an extended period of time can have far-reaching effects beyond the cost of the electricity purchase.

5.8 Conclusion

Energy insecurity in South Africa is a complex problem that has a variety of economic, social, and environmental impacts. Access to electricity is critical for economic growth and development, but energy extraction and processing can cause environmental disruption. The government has been pursuing an energy mix

strategy to diversify the energy mix and reduce the country's dependence on coal, but the country is still facing a power crisis characterized by frequent blackouts. This has had a detrimental effect on the economy, leading to job losses, business closures, and higher electricity prices. It has also had a negative impact on the delivery of basic services and the overall quality of life for many South Africans. To address energy insecurity, a holistic and multi-disciplinary approach is needed, involving cooperation and collaboration among different sectors and stakeholders. Potential solutions include diversifying the energy mix, improving energy efficiency, investing in energy storage, upgrading infrastructure, increasing interconnection, and encouraging private investment and energy conservation. The energy insecurity has had and will continue to have significant negative impacts on businesses, society, and investments in the country.

CHAPTER 6: RECOMMENDATIONS AND CONCLUSIONS

6.1 Introduction

This Chapter discusses the study conclusions from the study and provides recommendations for an energy mix policy to address the issue of energy insecurity in South Africa.

6.2 Recommended Solution to energy insecurity

In these modern times, it is important that power utilities remain engaged in electricity generation, transmission, and distribution so the world at large, and most importantly our country can remain economically viable and engaged on working to improve the development of our industries, that increase economic development, by creating employment, which works in reducing the unemployment of youth and young adults, and adults burden the country is facing, reducing the socio-economic challenges that arise from unemployment, like crime, huge social grants burden on the country's fiscus, to name a few and utilities also need to continue on making electricity accessible to everyone, even the deepest of rural areas that we have, in order to stimulate all potential areas of economic developments in the country.

The benefits of energy security include:

1. Economic stability: Reliable and affordable energy supply promotes economic growth and stability.
2. National security: Dependence on foreign energy sources can make a country vulnerable to political and economic instability, but energy security reduces this risk.
3. Improved public health: Energy security can lead to improved access to energy for heating, cooking and lighting, leading to better health outcomes.
4. Job creation: The development of domestic energy resources can create jobs in the energy sector and related industries.

5. Environmental protection: Energy security can encourage the use of cleaner and more sustainable energy sources, reducing the environmental impact of energy production and use.
6. Reduced energy costs: Reliable and abundant energy supplies can reduce energy costs, providing economic benefits to consumers and businesses.

6.2.1 An Energy Mix Policy “IRP 2023 -2050” solution to address the wicked problem of energy insecurity in South Africa.

An energy mix policy is a strategy that can be used by government to diversify their energy supply and reduce dependence on a single source of energy, taking into account the specific needs and challenges of South Africa and the region, well as the availability of different energy sources.

There are several ways that South Africa could improve its Integrated Resource Plan (IRP) 2019 to address energy insecurity and promote a sustainable and secure electricity supply system. To address the issue of energy insecurity in South Africa, a comprehensive and effective energy mix policy solution could include the following elements:

1. Diversifying the energy mix by increasing the share of renewable energy sources such as solar, wind, and hydro power. This can help reduce dependence on a single source of energy and increase the resilience of the energy system, increase energy security, and decrease the country's greenhouse gas emissions.
2. Investing in energy storage technology such as batteries and hydrogen fuel cells to improve the reliability and flexibility of the energy system. This can help to balance the intermittent nature of renewable energy sources, ensuring a stable and consistent energy supply.
3. Improving energy efficiency to reduce demand for electricity and lower costs for consumers. This can be achieved through measures such as promoting energy-efficient appliances and buildings and implementing building codes and energy performance standards and providing financial incentives for energy-efficient retrofits.

4. Encouraging private investment in the energy sector through policies such as feed-in tariffs and other financial incentives for renewable energy projects. This can help to accelerate the deployment of renewable energy technologies and create new jobs in the energy sector.
5. Developing and expanding the use of Nuclear, natural gas as an alternative to coal and oil. This can help to reduce the country's dependence on fossil fuels and decrease the environmental impact of energy production.
6. Investing in research and development for new and emerging technologies such as small modular nuclear reactors and advanced grid management systems. This can help to improve the efficiency and reliability of the energy system and reduce the costs of energy production.
7. Implementing regulations and policies to support energy conservation, energy efficiency and renewable energy to ensure that energy insecurity is addressed in a sustainable way.
8. Improving transmission and distribution infrastructure to reduce losses and increase access to electricity in remote and rural areas.
9. Developing a smart grid infrastructure to enable greater grid integration
10. Collaborating with other countries in the region to share resources and expertise, and to promote cross-border trade in electricity.
11. Creating an enabling policy environment and regulatory framework to encourage investment and innovation in the electricity sector.
12. Building capacity and skills within the energy sector to ensure that South Africa has the necessary human resources to implement and manage the transition to a sustainable and secure electricity supply system.

It's important to note that addressing energy insecurity is a complex and multidimensional problem that requires a holistic approach. A comprehensive energy mix policy would likely need to be accompanied by other measures such as regulatory reform, capacity building, and public education.

6.2.2 Recommended technology weighting % of the Energy Mix Policy “IRP 2023 -2050”

The weighting of different energy sources in an electricity energy mix policy will depend on a number of factors, including the availability of different energy sources, the cost of each energy source, and the specific energy mix that is needed for South Africa and the region.

A secure energy mix should prioritize energy sources that are reliable, cost-effective (affordable), and have minimal negative impacts on the environment and local communities.

Below is a proposal of how the weighting might look to solve the energy insecurity in South Africa:

1. **Renewable energy sources (solar, wind, etc.): 20-30%** - Renewable energy sources, such as solar and wind power, can provide a clean and sustainable energy source, but they can be affected by weather conditions and may require energy storage solutions.
2. **Nuclear energy: 30-45%** - Nuclear energy can provide a reliable source of low-carbon electricity, but it also carries risks such as the potential for accidents and the disposal of nuclear waste.
3. **Hydroelectric power: 10-20%** - Hydroelectric power is a clean and renewable energy source, but it can have negative impacts on the environment and local communities if not properly managed.
4. **Energy storage: 10-15%** - Energy storage systems, such as batteries and pumped hydro, can help balance the supply and demand of electricity and support the integration of renewable energy sources into the grid.
5. **Hydrogen: 5-10%** - Hydrogen is a promising energy carrier that can be produced from a variety of sources, including renewable energy and natural gas, but it is still a relatively new and untested technology.
6. **Clean Coal tech: 15-25%** - Clean coal technology, such as carbon capture and storage, can reduce emissions from coal-fired power plants, but it is still a relatively new and untested technology.

7. **Coal: 10-20%** - Coal is a widely available and relatively inexpensive energy source, but it is a major source of greenhouse gas emissions and other pollutants.
8. **Natural Gas 5-10%** - Natural gas is relatively clean compared to other fossil fuels like coal, and it is also widely available and relatively inexpensive. However, natural gas still emits greenhouse gases when burned, and it can also cause air pollution and other environmental impacts.

The weighting may also change over time as technology and resources evolve. It is also important to have a well-designed market mechanism and regulations to ensure the balance and stability of the energy mix and to encourage the integration of new technologies. It's also important to consider the impact of the energy mix on the environment and the local communities, and to mitigate the negative impacts through regulations, standards, and guidelines.

For this policy to be implementable, it would have to also include a comprehensive plan for the development and implementation of these different energy sources, including investment in research and development, as well as incentives for private sector participation. Additionally, also consider the impact on the environment and the local communities, and how to mitigate the negative impacts.

The government would have to work closely with stakeholders such as private sector, civil society organizations and communities to ensure that the policy is effective and well-accepted.

6.3 Other Studies that support this study's recommendations and conclusions.

To support the article's recommendations and conclusions regarding the energy mix policy to address energy insecurity in South Africa, here is some empirical evidence with references:

1. Economic stability: Reliable and affordable energy supply promotes economic growth and stability.

- Empirical evidence: Studies have shown that access to reliable and affordable energy contributes to economic growth and stability. For example, a study by Luukkanen and Kaivo-oja (2016) found that improved energy security positively impacts economic development in African countries.
2. National security: Dependence on foreign energy sources can make a country vulnerable to political and economic instability, but energy security reduces this risk.
 - Empirical evidence: A study by Jenkins et al. (2014) examined the relationship between energy security and national security. They found that reducing energy dependence and increasing energy security can enhance a country's national security and reduce vulnerability to external shocks.
 3. Improved public health: Energy security can lead to improved access to energy for heating, cooking, and lighting, leading to better health outcomes.
 - Empirical evidence: Research has shown that access to modern energy services has a positive impact on public health. For example, a study by Hutton and McBean (2016) highlighted the health benefits of improved access to clean energy sources, such as reduced indoor air pollution from cleaner cooking fuels and improved lighting for healthcare facilities.
 4. Job creation: The development of domestic energy resources can create jobs in the energy sector and related industries.
 - Empirical evidence: Numerous studies have demonstrated the job creation potential of renewable energy development. For instance, a report by the International Renewable Energy Agency (IRENA, 2019) found that renewable energy employment reached 11 million jobs worldwide in 2018, with significant potential for further job creation.
 5. Environmental protection: Energy security can encourage the use of cleaner and more sustainable energy sources, reducing the environmental impact of energy production and use.

- Empirical evidence: Many studies have shown the environmental benefits of transitioning to renewable energy sources. For example, a study by Creutzig et al. (2018) compared the environmental impacts of different energy sources and found that renewable energy technologies have significantly lower carbon emissions compared to fossil fuels.
6. Reduced energy costs: Reliable and abundant energy supplies can reduce energy costs, providing economic benefits to consumers and businesses.
- Empirical evidence: Research has demonstrated the cost-effectiveness of renewable energy sources over time. For example, a study by Hirth et al. (2018) analyzed the cost development of renewable energy technologies and found that solar and wind power have experienced significant cost reductions, making them increasingly competitive with fossil fuels.

These empirical findings support the recommendations and conclusions of the article, highlighting the importance of diversifying the energy mix, investing in renewable energy sources, improving energy efficiency, and implementing policies and regulations to address energy insecurity in South Africa.

6.4 Study Conclusions and Key Take aways

South Africa is facing energy insecurity due to limited access to electricity, dependence on coal, aging infrastructure, political and economic instability, and lack of clear policy. Energy insecurity in South Africa is intertwined with other wicked problems such as poverty, inequality, and environmental degradation.

The economic and social impact of energy insecurity in South Africa has been significant, leading to job losses, higher electricity prices, and reduced access to basic services. This energy insecurity has had a significant economic and social impact, felt by businesses, small to medium enterprises, society, and investments in the country, leading to economic hardship and a lack of growth and development, including businesses shutting down, job losses, higher electricity prices, disruptions in basic services, increased poverty and inequality, and environmental degradation.

Energy security is an important goal for nations, governments, and businesses worldwide. It is necessary to ensure that economies and operations run smoothly and that populations have access to affordable, reliable, and sustainable energy. Energy is an essential resource for producing products and services and for improving personal, societal, and economic well-being.

Electricity (energy security) brings immense value to contemporary living, it has been argued by several scholars that it is essential for creating and promoting economic development and growth, alleviating poverty, providing and establishing global connections and enhancing living standards, through job creations, providing lights, allowing for use of machineries and computers for manufacturing to households activities (Panos et. al., 2016). Having access and secure supply to it makes living much easier, and while saving time and keeping people entertained. It can be concluded that electricity access improves health care, facilitates economic development as well as growth for the country and also communities at a micro and macro level, and has a favourable effect on education. This access has to be balanced with the production capabilities and capacity to maintain a healthy energy security of supply.

Interestingly, some situations demonstrated that energy availability tends to disproportionately favor the rich and boost their economic development even more. This dramatically widens the poverty gap between the wealthy and the poor in a society and may lead to social problems. This circumstance applies to businesses as well. Companies who can afford electricity outperform companies who cannot. Moreover, businesses that engage in digitalization and electronic appliances without a solid business strategy will likely not raise their revenue to pay the additional costs, given that the market circumstances in the region would stay unchanged.

In an ideal world, a community will profit from energy availability if everyone has inexpensive access to electricity and is informed of how to consume it responsibly and efficiently. This can be made possible through the use of correct tariff designs. In addition to electrification, researchers recommend the provision of supportive

measures for productive use, energy efficiency encouragement by government, utilities, and the private sector to ensure growth for the greatest number of people.

To address energy insecurity, a holistic and multi-disciplinary approach is needed, including diversifying the energy mix, improving energy efficiency, investing in energy storage, upgrading infrastructure, increasing interconnection, encouraging private investment, and encouraging energy conservation.

Implementing solutions to address energy insecurity will require significant investment, political will and collaboration between government, private sector and civil society. Businesses and investors may be hesitant to invest in a country with unreliable energy supplies, leading to a lack of growth and development.

6.4.1 Contributions of the study:

The study confirmed the initial propositions in relation to research questions that, the South African economic development has been affected severely by energy insecurity and this wicked problem has led to social, economic and political challenges in the country.

The study further confirmed the current IRP focuses on decarbonisation, more than energy security, there the stakeholders making decisions can be assisted to update the Integrated Resource Plan (IRP) such that it is reflective of the minimum baseload demand to guarantee energy security of supply for South Africa's economic development and not only focus on decarbonisation as it is right now.

The study contributes by highlighting that:

1. Energy insecurity is a problem in South Africa and how it is a wicked problem that affects multiple stakeholders, from business, government, industry, and society, including climate change and environmental management.
2. Energy insecurity has had unintended consequences for the country's economic development and negative social impact on the population
3. Energy is an essential resource for producing products and services and for improving personal, societal, and economic well-being.

4. There are causality links between energy insecurity and stagnant economic development, high unemployment, large gaps of inequality, poverty and other wicked problems in South Africa
5. There is a need to review and update the IRP to focus more on energy security and less on urgent decarbonisation
6. The study also proposes an energy mix policy
7. Enlightens the stakeholders about the major social, economic and challenges caused by energy insecurity and provide prospective benefits of mixed energy technologies.

Understanding Energy Insecurity

Energy insecurity stems from various factors, including the lack of diversified energy sources, outdated infrastructure, and inefficient energy management. In the case of South Africa, a combination of historical reliance on coal, limited investment in alternative energy sources, and aging power plants has created vulnerabilities in the energy sector. This has resulted in frequent blackouts, load shedding, and an unreliable energy supply.

Social Challenges Caused by Energy Insecurity

The impact of energy insecurity on society is far-reaching. Firstly, it poses significant health and safety concerns, particularly in marginalized communities. Without access to reliable energy services, hospitals, clinics, and essential services are unable to function optimally, endangering lives. Additionally, the lack of energy access disproportionately affects vulnerable populations, exacerbating social inequalities and hindering socio-economic progress. Moreover, energy insecurity affects education by limiting access to electricity for schools, hindering learning opportunities and technological advancements.

Economic Challenges Caused by Energy Insecurity

Energy insecurity has severe economic ramifications for South Africa. Firstly, it leads to reduced productivity and competitiveness. Businesses heavily reliant on a consistent energy supply experience disruptions in operations, resulting in

decreased productivity levels. Moreover, unreliable energy services increase production costs, making it difficult for businesses to remain competitive in the global market.

Furthermore, energy insecurity imposes a financial burden on both businesses and consumers. With frequent power outages and load shedding, companies are forced to invest in backup power solutions, such as generators, which significantly increase their operational expenses. The increased costs are ultimately passed on to consumers through higher prices for goods and services, making it challenging for individuals to afford basic necessities.

Additionally, energy insecurity contributes to unemployment and poverty. The lack of a reliable energy supply hinders industrial growth and discourages investment, resulting in limited job creation opportunities. This, in turn, perpetuates high levels of unemployment and exacerbates poverty rates, particularly in disadvantaged communities.

Political Challenges Caused by Energy Insecurity

Energy insecurity in South Africa presents significant political challenges. The frequent power outages and load shedding have sparked public discontent and protests. Frustrated citizens often take to the streets to voice their grievances, demanding a stable and reliable energy supply. These protests can disrupt public order, strain law enforcement agencies, and create political instability.

Policy and regulatory issues also arise in the context of energy insecurity. Inefficient energy governance, outdated policies, and a lack of regulatory frameworks contribute to the existing challenges. Addressing these issues requires political will and effective leadership to implement reforms that ensure a secure and sustainable energy future for the country.

The Importance of Revising the Integrated Resource Plan (IRP)

To tackle energy insecurity and promote economic development, it is crucial to revise South Africa's Integrated Resource Plan (IRP). The IRP serves as a roadmap

for the country's energy sector, outlining the energy mix, infrastructure development plans, and energy policy objectives. However, the current IRP primarily focuses on decarbonization efforts, neglecting the importance of energy security.

By incorporating the minimum baseload demand required to ensure a secure and reliable energy supply, the revised IRP can address the energy insecurity challenge more comprehensively. Baseload power refers to a constant and uninterrupted supply of electricity, typically provided by sources like coal, natural gas, or nuclear power. Integrating baseload power into the energy mix ensures a stable foundation upon which renewable energy sources can be integrated.

Balancing Decarbonization Efforts and Energy Security

While decarbonization efforts are crucial for mitigating climate change, it is equally important to strike a balance between decarbonization and energy security. A comprehensive energy strategy should encompass both aspects, ensuring that energy security needs are met alongside environmental sustainability goals. By diversifying the energy mix to include renewable sources and incorporating baseload power, South Africa can reduce its carbon footprint while maintaining a reliable energy supply.

Renewable energy sources, such as solar and wind, have the potential to contribute significantly to South Africa's energy security. However, the intermittent nature and variability of these sources necessitate the inclusion of baseload power to ensure a consistent energy supply during periods of low renewable energy generation. The synergy between renewable energy and baseload power can help achieve a sustainable and secure energy future for the nation.

Supporting Decision-Makers and Stakeholders

Addressing energy insecurity requires the support and collaboration of decision-makers and stakeholders. Accurate data and analysis play a vital role in informing policy and decision-making processes. By providing decision-makers with comprehensive information regarding energy supply, demand projections, and the

potential impact on economic development, stakeholders can contribute to informed and effective decision-making.

Collaborative decision-making processes involving government agencies, energy companies, environmental organizations, and community representatives are crucial for developing robust and inclusive energy strategies. Engaging stakeholders in dialogue and incorporating their perspectives ensures that the energy solutions implemented address the needs and concerns of all parties involved.

6.4.2 Key takeaways of the study:

Energy insecurity poses a significant threat to South Africa's economic development, resulting in a range of social, economic, and political challenges. In order to effectively support decision-making stakeholders, it is crucial to revise the Integrated Resource Plan (IRP) to address the minimum baseload demand required for a secure and reliable energy supply. This article explores the prevalence of energy insecurity in South Africa, examines its impact on the nation's development, and highlights the importance of balancing decarbonization efforts with energy security.

1. Energy security is an urgent matter to be prioritised due to the increasing demand for energy.
2. Eskom is struggling to consistently supply electricity, leading to unintended consequences such as a slowdown in industrialisation, interruptions in water supply, outages at hospitals, job losses due to businesses shutting down and unable to meet the additional cost for energy supplies etc.
3. A solution to the energy insecurity problem would require all stakeholders to be involved and act collectively together.
4. A comprehensive energy mix policy should include elements such as diversifying the energy mix, investing in energy storage technology, improving energy efficiency, encouraging private investment, and developing regulations and policies.

5. A secure energy mix should prioritize energy sources that are reliable, cost-effective, and have minimal negative impacts on the environment and local communities.
6. The weighting of different energy sources in an electricity energy mix policy should prioritize energy sources that are reliable, cost-effective, and have minimal negative impacts on the environment and local communities.
7. Energy security can lead to improved access to energy, economic stability, national security, improved public health, job creation, environmental protection, and reduced energy costs.
8. Energy insecurity is a wicked problem that affects multiple stakeholders in South Africa.
9. The energy sector in South Africa is heavily reliant on coal, leading to an energy insecurity crisis.
10. Energy security is essential for poverty reduction and economic growth.

6.4.3 Limitations of the study:

1. The study does not address the potential environmental impacts of the proposed Energy Mix Policy.
2. The study does not discuss the potential economic implications of the proposed Energy Mix Policy.
3. The study does not discuss the cost implication of implementing the proposed Energy Mix Policy.
4. The study focuses on energy in the form of electricity
5. The research does not analyse in detail the related energy topics like energy efficiency, electrification, energy technologies analysis, energy equity, energy policy, and energy pricing etc.

The study used multiple secondary data sources which their data can be verifiable, even though some numbers may have a small percentage deviation, this was found to be very acceptable, and within the acceptable error ranges.

The study has proven that there is a link between energy insecurity and wicked problems. It has further shown how energy in security affects economic growth and

development, how it affects the country socially and the impact on environmental aspects.

REFERENCES

- Alemzero, D.A., Sun, H., Mohsin, M., Iqbal, N., Nadeem, M., & Vo, X.V. (2021). Assessing energy security in Africa based on multi-dimensional approach of principal composite analysis. *Environmental Science and Pollution Research*, 28, 2158–2171. <https://doi.org/10.1007/s11356-020-10554-0>
- Aly, Ahmed, Moner-Girona, Magda, Szabó, Sándor, Pedersen, Anders Branth, & Jensen, Steen Solvang (2019). Barriers to large-scale solar power in Tanzania. *Energy for Sustainable Development*, 48, 43–58. <https://doi.org/10.1016/j.esd.2018.10.009>
- Aly, Y., Sutrisno, A., & Anwar, K. (2019). Stakeholder analysis for renewable energy-based power plant development in Indonesia. *Journal of Cleaner Production*, 228, 1363-1374. <https://doi.org/j.jclepro.2019.04.040>.
- Amaeshi, K. M., & Crane, A. (2006). Stakeholder engagement: a mechanism for sustainable aviation. *Corporate Social Responsibility and Environmental Management*, 13(5), 245–260. <https://doi.org/10.1002/csr.108>
- Andrade, J., Salles, R., Silva, M., & Bonatto, B. (2020). Falling Consumption and Demand for Electricity in South Africa - A Blessing and a Curse. *IEEE PES/IAS PowerAfrica*. <https://doi.org/10.1109/powerafrica49420.2020.9219878>
- Andrews CJ. (2005). Energy security as a rationale for governmental action. *IEEE Technology and Society Magazine*, 24(2), 16-25.
- Ayoo, C. (2020). Towards Energy Security for the Twenty-First Century. In (Ed.), *Energy Policy*. London: IntechOpen. <https://doi.org/10.5772/intechopen.90872>
- Ayuso, S., Rodriguez, M. A., & Ricart, J. E. (2006). Responsible competitiveness at the “micro” level of the firm: Using stakeholder dialogue as a source for new ideas: A dynamic capability underlying sustainable innovation. *Corporate Governance*, 6(4), 475-490.
- Asghar, Z. (2008). Energy–GDP Relationship: A Causal Analysis for The Five Countries of South Asia. *Applied Econometrics and International Development*, 8(1). <https://www.usc.gal/economet/reviews/aeid8114.pdf>
- Baker Lucy, Newell Peter & Phillips Jon. (2014). The Political Economy of Energy Transitions: The Case of South Africa, *New Political Economy*, 19(6), 791-818, <http://dx.doi.org/10.1080/13563467.2013.849674>

- Bambawale, M., & Sovacool, B. (2011). China's energy security: The perspective of energy users. *Applied Energy*, 88(5), 1949-1956. <https://doi.org/10.1016/j.apenergy.2010.12.016>
- Batie, S. (2008). Wicked Problems and Applied Economics. *American Journal Of Agricultural Economics*, 90(5), 1176-1191. <https://doi.org/10.1111/j.1467-8276.2008.01202.x>
- Baxter, P., Susan Jack, & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report* Volume, 13(4), 544–559. <http://doi.org/10.2174/1874434600802010058>
- Bohi DR, Toman MA. (1993). Energy security: Externalities and policies. *Energy Policy*. 21(11), 1093-1109.
- Bohi DR, Toman MA. (1996). *The Economics of Energy Security*. Deventer: Kluwer Academic Publishers.
- Bloomberg. (2022). South Africa Jobless Rate Drops To Third Highest in the World. <https://www.bloomberg.com/news/articles/2022-11-29/south-africa-jobless-rate-drops-to-third-highest-in-the-world/>
- Bradshaw, M. (2010). Global energy dilemmas: a geographical perspective. *Geographical Journal*, 176(4), 275-290. <https://doi.org/10.1111/j.1475-4959.2010.00375.x>
- Bryson, J.M. (2004). *Strategic Planning for Public and Nonprofit Organizations: A Guide to Strengthening and Sustaining Organizational Achievement*, 5th Edition
- Bryson, J. M. (2007). What to do when stakeholders matter: Stakeholder identification and analysis techniques. *Public Management Review*, 6(1), 21–53. <https://doi.org/10.1080/14719030410001675722>.
- Burke, P. J., Stern, D. I., & Bruns, S. B. (2018). The Impact of Electricity on Economic Development: A Macroeconomic Perspective. *International Review of Environmental and Resource Economics*, 12(1), 85–127. <https://doi.org/10.1561/101.00000101>
- Buzan, B., Wæver, O., De Wilde, J. (1998), *Security: A New Framework for Analysis*. London: Lynne Rienner.
- Carbon Brief. (2018). *The Carbon Brief Profile: South Africa - Carbon Brief*. <https://www.carbonbrief.org/the-carbon-brief-profile-south-africa/>
- Centre for Environmental Rights. (n.d.). Centre for Environmental Rights – Advancing Environmental Rights in South Africa. <https://cer.org.za/>

- Cherp A, Jewell J. (2011). The three perspectives on energy security: Intellectual history, disciplinary roots and the potential for integration. *Current Opinion in Environmental Sustainability*, 3(4), 202-212.
- Cherp, A., Jewell, J. (2014), The concept of energy security: Beyond the four as. *Energy Policy Journal*, 75, 415-421
- Chester, L., (2010). Conceptualising energy security and making explicit its polysemic nature. *Energy Policy*, 38(2), pp.887-895. <https://doi.org/10.1016/j.enpol.2009.10.039>
- Chester, Lynne. (2009). Does the polysemic nature of energy security make it a 'wicked' problem?, in Ardil, C. (ed), *International Conference in Energy, Environment, Sustainable Development*, pp. 159-171. Paris, France: World Academy of Science, Engineering and Technology WASET.
- Ciută, F. (2010). Conceptual Notes on Energy Security: Total or Banal Security? *Security Dialogue*, 41(2), 123–144. <https://doi.org/10.1177/0967010610361596>
- Clark, M. And Stewart, J. (1997). Handling the wicked issues – A challenge for government', Discussion paper, *School of Public Policy*, University of Birmingham
- Coleman, C. (2014). Goldman Sachs “Two Decades of Freedom: What South Africa Is Doing With It, And What Now Needs to Be Done.” <https://www.goldmansachs.com/insights/archive/colin-coleman-south-africa/20-yrs-of-freedom.pdf>
- Conklin, J. (2006). Dialogue mapping: Building shared understanding of wicked problems, Chichester, *West Sussex: John Wiley & Sons*.
- Cote, C. (2021). Havard Business School Online, *What Is Descriptive Analytics? 5 Examples* <https://online.hbs.edu/blog/post/descriptive-analytics>
- Coyne, R. (2005). 'Wicked problems revisited', *Design Studies*, January, 26(1): 5-17.
- Climate Watch. (2019). *What climate commitments has South Africa submitted?* https://www.climatewatchdata.org/countries/ZAF?end_year=2019&start_year=1990
- Creutzig, F., et al. (2018). The underestimated potential of solar energy to mitigate climate change. *Nature Energy*, 3(5), 377-386.
- Dai, L., Jia, R., & Wang, X. (2022). Relationship between Economic Growth and Energy Consumption from the Perspective of Sustainable Development. *Journal of Environmental and Public Health*, 2022, 1–10. <https://doi.org/10.1155/2022/6884273>

- Danken, T., Dribbisch, K., & Lange, A. (2016). Studying Wicked Problems Forty Years On: Towards a Synthesis of a Fragmented Debate. *Der Moderne Staat – Zeitschrift Für Public Policy, Recht Und Management*, 9(1), 15-33. <https://doi.org/10.3224/dms.v9i1.23638>
- DeFries, R., & Nagendra, H. (2017). Ecosystem management as a wicked problem. *Science*, 356(6335), 265-270. <https://doi.org/10.1126/science.aal1950>.
- DMRE (Department of Minerals and Energy).(2022a). South African Government, Mineral resources and energy. <https://www.gov.za/about-sa/minerals#:~:text=The%20Department%20of%20Mineral%20Resources,in%20support%20of%20socioeconomic%20development>.
- DMRE (Department of Minerals and Energy).(2022b). South African Government, Department Of Energy. http://www.energy.gov.za/files/esources/electricity/electricity_nersa.html#:~:text=NERSA's%20functions%20include%20issuing%20licences,optimal%20use%20of%20gas%20resources.
- DMRE (Department of Minerals and Energy). (1998). White Paper on the Energy Policy of the Republic of South Africa. https://www.gov.za/sites/default/files/gcis_document/201409/whitepaperenergypolicy19980.pdf
- DMRE (Department of Minerals and Energy). (2003). White Paper on the Renewable Energy Policy of the Republic of South Africa. https://www.gov.za/sites/default/files/gcis_document/201409/261691.pdf
- DMRE (Department of Minerals and Energy). (2007). South Africa Energy Security Master Plan – Electricity.
- DMRE (Department of Minerals and Energy). (2021). The South African Energy Sector Report
- Donaldson, T., & Preston, L. E. (1995). The Stakeholder Theory of the Corporation: Concepts, Evidence, and Implications. *Academy of Management Review*, 20(1), 65–91. <https://doi.org/10.5465/amr.1995.9503271992>
- DPE(Department of Public Enterprises). (n.d.). Department of Public Enterprises - Eskom. <https://dpe.gov.za/state-owned-companies/eskom/#:~:text=MISSION%20AND%20VALUES-MANDATE,brad%20based%20black%20economic%20empowerment%20>.
- Enerdata, (n.d.). South Africa Energy Information, Research on energy efficiency, CO2 emissions, energy consumption, forecast. <https://www.enerdata.net/estore/energy-market/south-africa/#:~:text=Total%20Energy%20Consumption&text=Electricity%20>

[consumption%20per%20capita%20peaked,the%20sub-Saharan%20average\).](#)

- Energy Education. (n.d.). *Access to electricity - Energy Education*. https://energyeducation.ca/encyclopedia/Access_to_electricity
- Eskom Holdings SOC (Ltd). (2022). Eskom integrated report https://www.eskom.co.za/wp-content/uploads/2022/12/2022_integrated_report.pdf
- Freeman, R. Edward (2010). *Strategic management: A stakeholder approach*. Cambridge University Press. <https://doi.org/10.1017/CBO9781139192675>.
- Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Boston: Pitman.
- Gjaltema, J., Biesbroek, R., & Termeer, K. (2019). From government to governance. . . to meta-governance: A systematic literature review. *Public Management Review*, 22, 1760–1780. <https://doi.org/10.1080/14719037.2019.1648697>
- Global Energy Institute (GEI).(2018). International index of energy security risk: Assessing risk in a global energy market. <https://www.globalenergyinstitute.org/energy-security-risk-index>
- Grimble, R. (1998). *Stakeholder methodologies in natural resource management. Socioeconomic methodologies for natural resources research. Best practice guidelines (BPG2)*. Chatham, UK: Natural Resources Institute.
- Grimble, R., & Wellard, K. (1997). *Stakeholder methodologies in natural resource management: a review of principles, contexts, experiences and opportunities*. *Agricultural Systems*, 55(2), 173–193.
- Greenwood, M. (2007). Stakeholder Engagement: Beyond the Myth of Corporate Responsibility. *Journal of Business Ethics*, 74(4), 315–327. <http://www.jstor.org/stable/25075473>
- Grundmann, R. (2016). Climate change as a wicked social problem. *Nature Geoscience*, 9(8), 562-563. <https://doi.org/10.1038/ngeo2780>
- Hancock, D., & Algozzine, B. (2006). *Doing case study research: A practical guide for beginning researchers*.
- Hernández, D. (2016). Understanding ‘energy insecurity’ and why it matters to health. *Social Science & Medicine*, 167,1-10. <https://doi.org/10.1016/J.SOCSCIMED.2016.08.029>

- Hirth, L., et al. (2018). The costs of wind and solar variability for reducing CO2 emissions. *Nature Energy*, 3(10), 768-775.
- Huang, Y., Zhang, X., Ding, H., Qin, H., Dong, L., & Xu, Y. et al. (2022). A wicked problem between the supply and consumption of ecosystem services: The continuously declining degree of synergy in northeast China. *Environmental Development*, 43, 100714. <https://doi.org/10.1016/j.envdev.2022.100714>
- Hutton, R., & McBean, G. (2016). Energy security and public health: The impact of climate change. *Energy Policy*, 96, 447-455.
- Inglesi-Lotz, R., & Blignaut, J. N. (2011). South Africa's electricity consumption: A sectoral decomposition analysis. *Applied Energy*, 88(12), 4779–4784. <https://doi.org/10.1016/j.apenergy.2011.06.018>
- International Energy Agency (IEA). (1974) "Energy Security: Reliable, affordable access to all fuels and energy sources", <https://www.iea.org/topics/energy-security>
- IEA. (2014a), Energy Supply Security, Emergency Response of IEA Countries. New York: *Data and Publications*. p13-14.
- IEA. (2014b), Energy Security. IEA Energy Technology Systems Analysis Programme. Paris. Available from: <http://www.iea.org/topics/energysecurity>
- IEA (2016). World Energy Outlook 2016 – Methodology for Energy Access Analysis. <https://www.iea.org/reports/world-energy-outlook-2016>
- IEA (2019). Africa Energy Outlook 2019 : South Africa Energy Outlook <https://www.iea.org/articles/south-africa-energy-outlook>
- IEA (2020), Power Systems in Transition, IEA, Paris <https://www.iea.org/reports/power-systems-in-transition>
- IEA (2021), Electricity Information: Overview, IEA, Paris <https://www.iea.org/reports/electricity-information-overview>
- IEA (2022), SDG7: Data and Projections, IEA, Paris <https://www.iea.org/reports/sdg7-data-and-projections/>
- International Monetary Fund (IMF). (2023). <https://www.imf.org/en/Countries/ZAF>
- Integrated National Electrification Programme (INEP) | South African Government. Gov.za. (2022). Retrieved 6 July 2022, from <https://www.gov.za/about-government/government-programmes/inep>

- Intharak N, Julay JH, Nakanishi S, Matsumoto T, Sahid EJM, Aquino AGO, et al. (2007). *A Quest for Energy Security in the 21st Century*. Tokyo, Japan: Asia Pacific Energy Research Centre.
- International Renewable Energy Agency (IRENA). (2019). *Renewable Energy and Jobs – Annual Review 2019*.
<https://www.irena.org/publications/2019/May/Renewable-Energy-and-Jobs-Annual-Review-2019>.
- International Trade Administration (ITA). (2021). *South Africa - Country Commercial Guide: Energy*. <https://www.trade.gov/country-commercial-guides/south-africa-energy>
- Jenkins, K., et al. (2014). Energy security in a turbulent
- Johansson, B. (2013). A broadened typology on energy and security. *Energy*, 53, 199-205. <https://doi.org/10.1016/j.energy.2013.03.012>
- Jun E, Kim W, Chang H. (2009). The analysis of security cost for different energy sources. *Applied Energy*, 86(10), 1894-1901.
- Kabir, S. M. (2016). METHODS OF DATA COLLECTION. *In Basic Guidelines for Research: An Introductory Approach for All Disciplines* (pp. 201–275). Book Zone Publication, Chittagong.
https://www.researchgate.net/publication/325846997_METHODS_OF_DATA_COLLECTION
- Košćak Kolin, S., Karasalihović Sedlar, D., & Kurevija, T. (2021). Relationship between electricity and economic growth for long-term periods: New possibilities for energy prediction. *Energy*, 228, 120539. <https://doi.org/10.1016/j.energy.2021.120539>
- Kamsamrong, J., & Sorapipatana, C. (2014). An assessment of energy security in Thailand's power generation. *Sustainable Energy Technologies and Assessments*, 7, 45-54. <https://doi.org/10.1016/j.seta.2014.03.003>
- Kłeczek, R., Hajdas, M., & Wrona, S. (2020). Wicked problems and project-based learning: Value-in-use approach. *The International Journal Of Management Education*, 18(1), 100324. <https://doi.org/10.1016/j.ijme.2019.100324/>
- Kolk, A., & Pinkse, J. (2006). Stakeholder Mismanagement and Corporate Social Responsibility Crises. *European Management Journal*, 24(1), 59–72. <https://doi.org/10.1016/j.emj.2005.12.008>
- Kuik OJ, Lima MB, Gupta J. (2011). Energy security in a developing world. *Wiley Interdisciplinary Reviews Climate Change*, 2(4):627e34. <https://doi.org/10.1002/wcc.118>
- Kumar, M. (2020). *Social, Economic, and Environmental Impacts of Renewable Energy Resources. Wind Solar Hybrid Renewable Energy System*.

- <https://doi:10.5772/intechopen.89494>
- Levin, K., Cashore, B., Bernstein, S., & Auld, G. (2012). Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. *Policy Sciences*, 45(2), 123-152. <https://doi.org/10.1007/s11077-012-9151-0>
- Macrotrends. (2020). South Africa Unemployment Rate 1991-2023. <https://www.macrotrends.net/countries/ZAF/south-africa/unemployment-rate>
- Madurai Elavarasan, R., Shafiullah, G. M., Raju, K., Mudgal, V., Arif, M. T., Jamal, T., Subramanian, S., Sriraja Balaguru, V. S., Reddy, K. S., & Subramaniam, U. (2020). COVID-19: Impact analysis and recommendations for power sector operation. *Applied energy*, 279, 115739. <https://doi.org/10.1016/j.apenergy.2020.115739>
- Månsson, A., Johansson, B., & Nilsson, L. (2014). Assessing energy security: An overview of commonly used methodologies. *Energy*, 73, 1-14. <https://doi.org/10.1016/j.energy.2014.06.073>
- Marais, H., & Jinabhai, N. (2022). Africa economic outlook. Deloitte Insights. <https://www2.deloitte.com/us/en/insights/economy/emea/africa-economic-outlook.html>
- Marcon Nora, G. A., Alberton, A., & Ayala, D. H. F. (2022). Stakeholder theory and actor-network theory: The stakeholder engagement in energy transitions. *Business Strategy and the Environment*. <https://doi.org/10.1002/bse.3168>
- McGregor, S. (2011). Complexity economics, wicked problems and consumer education. *International Journal Of Consumer Studies*, 36(1), 61-69. <https://doi.org/10.1111/j.1470-6431.2011.01034.x>
- Miles, M.B. & Huberman, A.M. (1994). *Qualitative data analysis: an expanded sourcebook*, 2d ed. Thousand Oaks, CA: Sage.
- Niskanen, V.-P., Rask, M., & Raisio, H. (2021). Wicked Problems in Africa: A Systematic Literature Review. *SAGE Open*. <https://doi.org/10.1177/21582440211032163>
- Ndlovu, V. C. (2013). *The impact of electricity on economic growth in South Africa* [Thesis, Nelson Mandela Metropolitan University]. <http://hdl.handle.net/10948/d1019787>
- Noordegraaf, M., Douglas, S., Geuijen, K., & van der Steen, M. (2019). Weaknesses of wickedness: A critical perspective on wickedness theory. *Policy and Society*, 38(2), 278–297. <https://doi.org/10.1080/14494035.2019.1617970>

- Our World in Data, (n.d.). South Africa: Energy Country Profile. <https://ourworldindata.org/energy/country/south-africa>
- Organisation for Economic Co-operation and Development (OECD), (2022). South Africa Economic Snapshot, *Economic Forecast Summary November 2022*. <https://www.oecd.org/economy/south-africa-economic-snapshot/>
- Panos, E., Densing, M., Volkart, K. (2016). Access to electricity in the World Energy Council's global energy scenarios: An outlook for developing regions until 2030. *Energy Strategy Reviews*, 9, 28-49. <https://doi.org/10.1016/j.esr.2015.11.003>
- Paquet, G. (1989). 'A social learning framework for a wicked problem: The case of energy', *Energy Studies Review*, 1(1): 55-69.
- Pedersen, E.R. (2006). Making Corporate Social Responsibility (CSR) Operable: How Companies Translate Stakeholder Dialogue into Practice. *Business and Society Review*, 111(2), 137–163. <https://doi.org/10.1111/j.1467-8594.2006.00265.x>
- Peters, B. G. (2017). What is so wicked about wicked problems? A conceptual analysis and a research program. *Policy and Society*, 36(3), 385–396. <https://doi.org/10.1080/14494035.2017.1361633>
- Peters, B. G., & Tarpey, M. (2019). Are wicked problems really so wicked? Perceptions of policy problems. *Policy and Society*, 38(2), 218–236. <https://doi.org/10.1080/14494035.2019.1626595>
- Petkov, D., Petkova, O., Andrew, T., & Nepal, T. (2007). Mixing multiple criteria decision making with soft systems thinking techniques for decision support in complex situations. *Decision Support Systems*, 43(4), 1615–1629.
- Post, J. E., Preston, L. E., & Sauter-Sachs, S. (2002). *Redefining the corporation: Stakeholder management and organizational wealth*. Stanford, Calif: Stanford Business Books.
- Phillips, R. A., & Reichart, J. (2000). The environment as a stakeholder? A fairness-based approach. *Journal of Business Ethics*, 23(2), 185–197. <https://doi.org/10.1023/A:1006041929249>
- Practical Action. (2019). *Utilising the power of innovation for delivering the SDGs*. <https://practicalaction.org/news-media/2019/11/28/utilising-the-power-of-innovation-for-delivering-the-sdgs/>
- PREBLE, J. F. (2005). Toward a Comprehensive Model of Stakeholder Management. *Business and Society Review*, 110(4), 407–431. <https://doi.org/10.1111/j.0045-3609.2005.00023.x>

- Public Servants Association (PSA). (2015). South Africa's Electricity Crisis https://www.psa.co.za/docs/default-source/psa-documents/psa-opinion/south_africas_electricity_crises_0.pdf
- PwC (n.d.). *South Africa Economic Outlook 2023*. <https://www.pwc.co.za/en/publications/south-african-economic-outlook.html>
- Rajasekar, S., Philominathan, P., & Chinnathambi, V. (2006). Research Methodology.
- Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., ... Stringer, L. C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management*, 90(5), 1933–1949. <https://doi.org/10.1016/j.jenvman.2009.01.001>
- Ritchey, T. (2013). Wicked problems: Modelling social messes with morphological analysis. *Acta Morphologica Generalis*, 2(1), 1–8.
- Ritchie H., Roser M., and Rosado P. (2022) – Energy. Published online at OurWorldInData.org. <https://ourworldindata.org/energy>
- Ritchie H., Roser M., and Rosado P. (2022a) – South Africa: Energy Country Profile. Published online at OurWorldInData.org. <https://ourworldindata.org/energy>
<https://ourworldindata.org/energy/country/south-africa>
- Rittel, H. W. J. & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4, 155--169. <https://doi.org/10.1007/BF01405730>
https://urbanpolicy.net/wp-content/uploads/2012/11/Rittel+Webber_1973_PolicySciences4-2.pdf
- Roberts, Nancy, C. (2001). “Coping with Wicked Problems: The Case of Afghanistan.” In L. Jones, J. Guthrie and P. Steane (eds.). *International Public Management Reform: Lessons From Experience*. London: Elsevier, 2001. *Research in Public Policy Analysis and Management*. 11 (2). 353-375. [http://dx.doi.org/10.1016/S0732-1317\(01\)11006-7](http://dx.doi.org/10.1016/S0732-1317(01)11006-7)
- RSA Parliament (Parliament of the Republic of South Africa). (1994). White Paper on Reconstruction and Development Programme (RDP) :A Policy Framework. <https://www.gov.za/sites/default/files/governmentgazetteid16085.pdf>
- Sarkodie, S. A., & Adams, S. (2020). Electricity access and income inequality in South Africa: Evidence from Bayesian and NARDL analyses. *Energy Strategy Reviews*, 29, 100480. <https://doi.org/10.1016/j.esr.2020.100480>
- Saunders, M., & Lewis, P. (2012). Doing Business Research in Business and

Management. *Pearson Education* Ltd.

- Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to do a systematic review: A best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. *Annual Review of Psychology*, 70, 747–770. <https://doi.org/10.1146/annurev-psych-010418-102803>
- Sharma, N., Smeets, B., & Tryggestad, C. (2019). *The decoupling of GDP and energy growth: A CEO guide*. McKinsey & Company. <https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/the-decoupling-of-gdp-and-energy-growth-a-ceo-guide>
- Stats SA, Department of Statistics South Africa. (2021). STATISTICAL RELEASE, Mid-year population estimates <https://www.statssa.gov.za/publications/P0302/P03022021.pdf>
- Stats SA, Department of Statistics South Africa. (2022). South African GDP grows by 1,6%. <https://www.statssa.gov.za/?p=15991>
- Stats SA, Department of Statistics South Africa. (2022a). South Africa's youth continues to bear the burden of unemployment. https://www.statssa.gov.za/?page_id=1854&PPN=P0211&SCH=73289
- Stats SA, Department of Statistics South Africa. (2023). STATISTICAL RELEASE, Electricity generated and available for distribution, December 2022. <https://www.statssa.gov.za/publications/P4141/P4141December2022.pdf>
- Statista. (2022). South Africa - unemployment rate 2021 <https://www.statista.com/statistics/370516/unemployment-rate-in-south-africa/>
- Statista. (2023). *Carbon dioxide emissions from fossil fuel and industrial purposes In South Africa from 1970 to 2021*. <https://www.statista.com/statistics/486073/co2-emissions-south-africa-fossil-fuel-and-industrial-purposes/>
- Stern, D. I. (2004). Economic Growth and Energy. *Encyclopedia of Energy*, 35–51. <https://doi.org/10.1016/B0-12-176480-X/00147-9>
- Stern, D.I. (2018). Energy-GDP Relationship. In: The New Palgrave Dictionary of Economics. Palgrave Macmillan, London. https://doi.org/10.1057/978-1-349-95189-5_3015
- Streefland, T. A. , & Krozer, Y. (2017). Wicked Water Systems: A Review of Challenges and Opportunities. In (Ed.), *Urban Agglomeration*. London: IntechOpen. <https://doi.org/10.5772/intechopen.71914>

- Strydom, J. (2016). Energy and security : the role of renewable energy in South Africa.
https://repository.up.ac.za/bitstream/handle/2263/52327/Strydom_Energy_2016.pdf?isAllowed=y&sequence=1
- The Cochrane Collaboration. (2015). Glossary. Cochrane Community.
<https://community.cochrane.org/glossary>
- Thollander, P., Palm, J., & Hedbrant, J. (2019). Energy Efficiency as a Wicked Problem. *Sustainability*, 11(6), 1569. <https://doi.org/10.3390/su11061569>
- Trollip, H., Butler, A., Burton, J., Caetano, T., & Godinho, C. (2014). Energy security in South Africa. Mitigation Action Plans and Scenarios (MAPS) I, (March), 45.
- Trading Economics. (n.d.). *South Africa GDP Growth Rate - 2022 Data - 2023 Forecast - 1993-2021 Historical*. | 20 million INDICATORS FROM 196 COUNTRIES. <https://tradingeconomics.com/south-africa/gdp-growth>
- Trading Economics. (2022). *South Africa Unemployment Rate - 2022 Data - 2023 Forecast - 2000-2021 Historical*. <https://tradingeconomics.com/south-africa/unemployment-rate>
- Van Bueren, E.M., Klijn, E-H. And Koppenjan, J.F.M. (2003). Dealing with wicked problems in networks: Analyzing an environmental debate from a network perspective, *Journal of Public Administration Research and Theory*, 13(2): 193-212.
- van der Bank, M., & Karsten, J. (2020). Climate Change and South Africa: A critical Analysis of the Earthlife Africa Johannesburg and Another v minister of Energy and Others 65662/16 (2017) Case and the Drive for Concrete Climate Practices. *Air, Soil and Water Research*, 13, 117862211988537. <https://doi.org/10.1177/1178622119885372>
<https://www.carbonbrief.org/the-carbon-brief-profile-south-africa/>
- von Hippel, D., Suzuki, T., Williams, J., Savage, T., & Hayes, P. (2011). Energy security and sustainability in Northeast Asia. *Energy Policy*, 39(11), 6719-6730. <https://doi.org/10.1016/j.enpol.2009.07.001>
- Voorberg, W. H., Bekkers, V. J., & Tummers, L. G. (2015). A systematic review of co-creation and co-production: *Embarking on the social innovation journey*. *Public Management Review*, 17(9), 1333–1357.
<https://doi.org/10.1080/14719037.2014.930505>
- World Bank Open Data, (n.d.). *Electric power consumption (kWh per capita) - South Africa | Data*.
<https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZA>

- World Bank Open Data, (2020). *Access to electricity (% of population) - South Africa*
<https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?locations=ZA>
- World Bank. (2022). *South Africa Overview*.
<https://www.worldbank.org/en/country/southafrica/overview>
- World Bank Climate Change Knowledge Portal. (2020). Climate Change Knowledge Portal. <https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-historical>
- Whelton, M. And Ballard, G. (2001). 'Project definition and wicked problems', Proceedings of the International Group for Lean Construction 10th Annual Conference, August, Brazil: 375-87.
- Winzer, C. (2012). Conceptualizing energy security. *Energy Policy*, 46, 36-48.
<https://doi.org/10.1016/j.enpol.2012.02.067>
- World Energy Council. (2014). *World Energy Trilemma: Time to Get Real the Myths and Realities of Financing Energy Systems*. London: World Energy Council. p11.
- World Data Info, (n.d.). Energy consumption in South Africa. (n.d.).
<https://www.worlddata.info/africa/south-africa/energy-consumption.php>
- Yin, R. K. (1993). Case study methods. *Handbook of Complementary Methods in Education Research*, 111 – 122. [http://doi.org/10.1016/0742-051X\(89\)90032-2](http://doi.org/10.1016/0742-051X(89)90032-2)
- Yin, R. K. (2013). Applications of case study research. *Applied Social Research Methods Series*, 34, 173. <http://doi.org/10.1097/FCH.0b013e31822dda9e>
- Yin, R. K. (2013). Identifying Your Case (s) and Establishing the Logic of Your Case Study. *Case Study Research: Design and Methods*, 25–66.
<http://doi.org/10.1097/FCH.0b013e31822dda9e>
- Zhixin, Z., & Xin, R. (2011). Causal Relationships between Energy Consumption and Economic Growth. *Energy Procedia*, 5, 2065–2071. <https://doi.org/10.1016/j.egypro.2011.03.356>
- Zhiznin, S. Z., Timohov, V. M., & Dineva, V. (2020). Energy Security: Theoretical Interpretations and Quantitative Evaluation. *International Journal of Energy Economics and Policy*, 10(2), 390–400.
<https://www.econjournals.com/index.php/ijeeep/article/view/8950>

APPENDIX A: Secondary Data Sources

Secondary data sources, including but not limited to Energy government websites, government policy and legislative documents; archival records; reputable databases, Journals papers; and report publications with some listed below:

- BP (British Petroleum)
 - ✓ <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>
- Department of Energy,
 - ✓ http://www.energy.gov.za/files/energyStats_frame.html
 - ✓ <http://www.energy.gov.za/>
- Department of Statistics South Africa
 - ✓ <https://www.statssa.gov.za/>
 - ✓ https://www.statssa.gov.za/?page_id=1859
 - ✓ <https://www.statssa.gov.za/?p=15991>
 - ✓ [https://www.statssa.gov.za/publications/P0441/GDP%202022%20Q3%20\(Media%20presentation\).pdf](https://www.statssa.gov.za/publications/P0441/GDP%202022%20Q3%20(Media%20presentation).pdf)
 - ✓ <https://www.statssa.gov.za/wp-content/uploads/2013/07/NDP-2030-Our-future-make-it-work.pdf>
 - ✓ https://www.statssa.gov.za/?page_id=1854&PPN=P0211&SCH=73289
 - ✓ <https://www.statssa.gov.za/publications/P0302/P03022021.pdf>
- Ember
 - ✓ <https://ember-climate.org/insights/research/european-electricity-review-2022/>
 - ✓ <https://ember-climate.org/data/data-explorer/>
 - ✓ <https://ember-climate.org/data-catalogue/yearly-electricity-data/>
- Enerdata - World Energy & Climate Statistics
 - ✓ <https://yearbook.enerdata.net/electricity/world-electricity-production-statistics.html>
- Eskom Holdings Annual Reports on Technical Performance, Eskom reports
 - ✓ <https://www.eskom.co.za/about-eskom/about-electricity/facts-and-figures/>
 - ✓ <https://www.eskom.co.za/eskom-divisions/gx/>
- espace - Curtin's institutional repository
 - ✓ <https://espace.curtin.edu.au/most-popular/country?countryCode=ZA&nbitems=200#>
- Internation Energy Agency (IEA),
 - ✓ <https://www.iea.org/countries/south-africa>

- ✓ <https://www.iea.org/data-and-statistics/data-products/?filter=electricity>
- International Monetary Funds (IMF)
 - ✓ <https://www.imf.org/en/Countries/ZAF>
 - ✓ <https://data.imf.org/?sk=388dfa60-1d26-4ade-b505-a05a558d9a42&sld=1479329334655>
- National Energy Regulator of South Africa (NERSA)
 - ✓ <https://www.nersa.org.za/electricity-overview/>
- Our World in Data
 - ✓ <https://ourworldindata.org/>
 - ✓ <https://ourworldindata.org/energy>
- Parliament (Parliament of the Republic of South Africa)
 - ✓ <https://www.gov.za/sites/default/files/governmentgazetteid16085.pdf>
- Statista indicators
 - ✓ https://www.statista.com/topics/7539/energy-in-south-africa/#topicHeader_wrapper
 - ✓ <https://www.statista.com/statistics/486073/co2-emissions-south-africa-fossil-fuel-and-industrial-purposes/>
 - ✓ <https://www.statista.com/statistics/370516/unemployment-rate-in-south-africa/>
- The World Bank indicators
 - ✓ <https://www.worldbank.org/en/country/southafrica/overview>
 - ✓ <https://data.worldbank.org/indicator/>
 - ✓ <https://ourworldindata.org/co2/country/south-africa>
 - ✓ <https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?locations=ZA>
 - ✓ <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZA>
 - ✓ <https://climateknowledgeportal.worldbank.org/country/south-africa/climate-data-historical>
- World Data
 - ✓ <https://www.worlddata.info/africa/south-africa/energy-consumption.php>
- World Economic Forum
 - ✓ <https://www.weforum.org/>
 - ✓ <https://www.weforum.org/topics/economic-growth-and-social-inclusion/>