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Sigenu, Khunjulwa

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The Investigation on Sustainable Security of Gas Supply as an Energy Transition Tool Towards Net Zero – 2050 in South Africa

Khunjulwa Sigenu

A research report 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 Management in Energy Leadership

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ABSTRACT

This paper investigates the sustainable security of gas supply as an energy transition tool. Questions were asked with a view to finding the middle ground in the debate among policy makers, academics, energy specialists and the business community. The questions covered (i) Key factors influencing the current and future sustainable gas supply in South Africa (ii) The interaction between social, economic, and environmental factors affecting sustainable security of gas supply in South Africa. (iii)Strategies that can be developed to improve the sustainable security of gas supply and their effects on the energy transition in South Africa; (iv) The importance of public-private sector collaboration in ensuring sustainable security of gas supply.

South Africa's energy landscape is undergoing a transition to reduce greenhouse gas emissions and improve energy mix diversification by reducing reliance on coal in favour of renewable energy sources. In this regard, gas is favoured as a transition energy source to complement solar, wind, battery storage sources, by policy makers (IRP2019). Gas may continue to be part of South Africa's energy mix for longer than anticipated.

South Africa is a net gas importer; it depends on gas imports from Mozambique because it does not have huge domestic gas reserves to support its domestic gas market. According to the Department of Minerals and Energy Resources, gas contributes about 3% to the total energy mix of the country (www.dmre.gov.za).

This report considers strategies that can assist South Africa to achieve sustainable security of gas supply, as the country transactions towards a regime of clean and renewable energy.

The interplay between economic, environmental and social factors is central to the conceptual analysis. Data collection was conducted through surveys and structured interviews; the quantitative data used mostly relied on the targets set in the Integrated Resource Plan (IRP, 2019) for gas's contribution to dispatchable capacity.

The research philosophy of this study is pragmatic. It acknowledges the complexity of sustainable security of gas supply and the need for an interdisciplinary understanding. This means that gas supply security is not only an economic issue but also a social and environmental construct, shaped by the interactions and meanings of various stakeholders. By acknowledging the role of social constructs, this study can explore how sustainable security is negotiated and contested among various stakeholders,

including policymakers, industry players, and civil society. This ontological stance enables the study to examine the complex interplay between technical, economic, and social factors that influence sustainable security.

The key findings are: (i) an urgent need for the development of a diversified gas market, (ii) investing in infrastructure and technology, (iii) an investment-friendly policy and regulatory environment, and (iv) improved public-private sector collaboration.

The report highlights the opportunities and challenges of the role of gas as a transition energy source. As the country moves away from coal dependency to a more diversified energy system, gas plays a complementary role to renewable energy. The importance of gas lies in the provision of reliable energy to support the decarbonisation path of the country. At the same time, it points to the environmental effects of gas in the long term.

KEY WORDS

Gas as transition energy tool; security of energy supply; security of gas supply; sustainable gas supply; gas infrastructure; indigenous gas market; regional integration.

DECLARATION

I, Khunjulwa Sigenu, declare that this research report 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 Master of Management in Energy Leadership at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Khunjulwa Sigenu

Signature: 

Signed at … SUNNINGHILL on the 23rd day of September 2025.

DEDICATION

I dedicate this research to my family, to my son Somila, and to myself.

ACKNOWLEDGEMENTS

I would express my sincere gratitude to my supervisor, Dr Nandi Malumbazo, for her valuable guidance, support and encouragement throughout this process of research and writing. Her insights have been instrumental in shaping my understanding and improving my work. I cannot forget her patience in times of difficulty. I also thank my colleagues for guided assistance up to this point.

Thank you for your patience.

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LIST OF ACRONYMS AND ABBREVIATIONS

AEC	African Energy Chamber
BUSA	Business Unity South Africa
CSIR	Council for Scientific and Industrial Research
DMR	Department of Mineral Resources
DMRE	Department of Mineral Resources and Energy
EIA	U.S. Energy Information Administration
FSRU	floating storage regasification unit
GMP	Gas Master Plan
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
MDGs	United Nations Millennium Development Goals
Mintek	Council for Mineral Technology
NDP	National Development Plan
NERSA	National Energy Regulator of South Africa
NGO	non-governmental organisation
R&D	research and development
SADC	Southern African Development Community
SAESR	South African Energy Sector Report
SMME	small, medium and micro-enterprises
SANEDI	South African National Energy Development Institute
Tcf	trillion cubic feet

CHAPTER 1. INTRODUCTION

1.1 Background

The South African energy landscape continues to be dominated by coal for electricity generation, which accounts for approximately 70% of its electricity supply (SAESR, 2022). The country is under pressure to transition its fossil-fuel-dominated energy system towards clean and renewable sources of energy.

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC, 1992) and its Paris Agreement (UNFCCC, 2015), South Africa is expected to honour its climate mitigation targets, which were set out in a nationally determined contribution (NDC) in 2021.

The Integrated Resources Plan 2019 (IRP, 2019) serves as the nation's strategic framework for electricity infrastructure development, detailing the energy mix requirements that will deliver reliable and sustainable energy supply.

In this context, gas is poised to play a pivotal role as a transition energy within the diversified energy mix. The South African government expressed the intention to pursue gas-fired electricity generation and facilitate investment and competition to roll out universal access to electricity throughout the country. Gas peaking plants will ramp up production when renewables are not generating enough electricity.

Gas is a fossil fuel, and not as clean as renewables, but it emits less carbon than coal and oil. and it provides flexibility and reliability for electricity generation (IEA, 2022).

The challenge with gas supply is that South Africa is a gas-constrained country, currently relying on gas imports from Mozambique to service about 90% of the industrial gas market (www.dmre.gov.za). Since the arrival of the first gas from Mozambique in 2004, the gas market has evolved significantly, with the construction of pipelines, storage facilities, and electricity generation plants (www.nersa.org.za). Despite these advancements, the gas market remains stagnant and underdeveloped by global standards. There has not been significant investment to meet the growing demand.

At the same time, the country is facing a looming go shortage, anticipated in 2027, according to Sasol Gas, the sole importer of gas into South Africa. Although it was recently reported in the media that Sasol Gas now expects that shortage in 2028, gas remains a constrained energy source.

In the longer term, there is potential for both onshore and offshore gas developments, in fields such as Brulpadda and Luiperd, Orange Basin, and the Karoo, among other regions. But *Engineering News* has reported that South Africa's discoveries remain a long way off, in terms of time and funding, from development. Until these resources come on stream, an impending gas shortage undermines South Africa's near-term future dependence on it (www.engineeringnews.co.za).

1.2 The Purpose

The purpose of the study is to investigate the strategies that South Africa can adopt to achieve sustainable security of gas supply. This will be achieved not only for electricity generation but to support the growing demand from other sectors of the economy. The limited gas supply from Mozambique is reportedly facing depletion, hence, South Africa must have realistic and achievable strategies to increase gas resources.

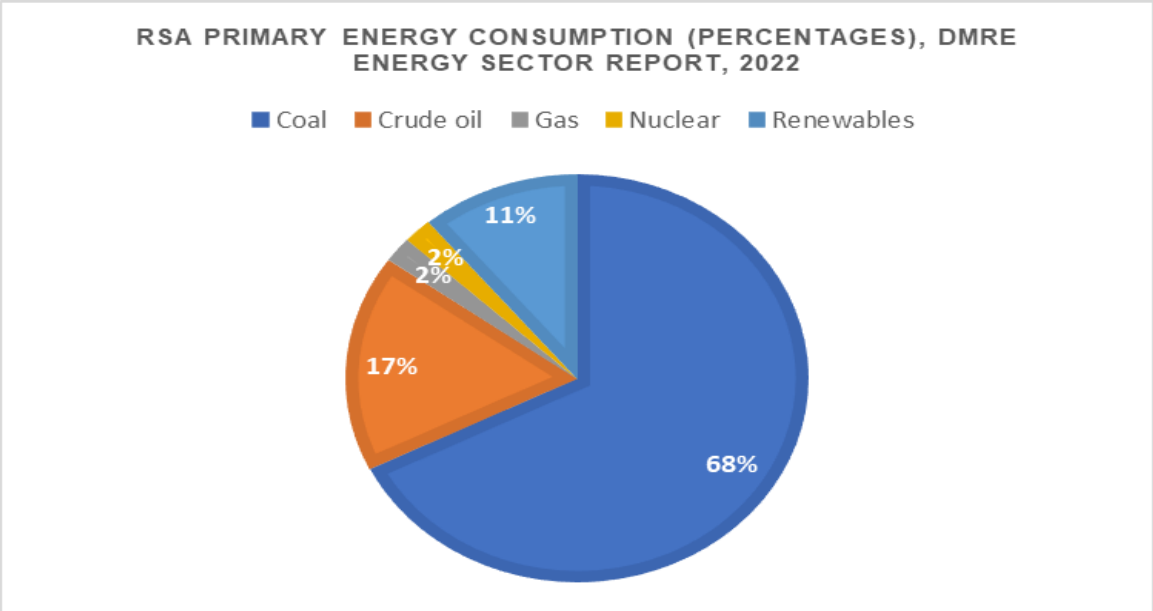
This research report looks at what steps should be taken to increase gas's contribution to the energy mix, as the country diversifies energy sources away from coal dependence. The study aims to contribute to the ongoing policy debate, by industry players, academics, energy specialists, business sector and policy makers on different approaches to achieving sustainable gas supply in South Africa.

1.3 Context of the study

South Africa's energy landscape is experiencing a major shift to reduce greenhouse gas emissions for electricity generation. Efforts to move away from over-reliance on coal are underway. Gas is recognized as a cleaner-burning alternative to coal and oil, emitting less CO2 than other fossil fuels (IEA, 2024). Studies confirm that gas can assist in reducing greenhouse gas emissions in the short term, although unintended long- term effects might hinder the transition into renewables (Gürsan & de Gooyert, 2021). S&P Global (March 2024) also supports the use of gas in steps towards decarbonization, as it helps stabilize the grid, providing balance to the variable generation of electricity from wind and solar. Gas-fired generation keep the electricity

system balanced. The role of gas in the energy mix cannot be overstated, given the forecast contribution of 8100 MW of gas-fired electricity by 2030: translating to between 10% and 15% of electricity generation, as per IRP 2019 targets.

Figure 1 below show South Africa's balance. Gas's contribution is between 2% and 3% and is projected to increase to 15%.



SOURCE: DMRE2022 ENERGY REPORT

Figure 1.1: Energy Balance of South Africa

1.4 Research problem

The current contribution of gas to the total energy mix is up to 3% according to the Department of Minerals and Energy Resources. In addition, the gas infrastructure is limited, to the ROMPCO cross-border pipeline from Mozambique to South Africa.

The sustainable security of the gas supply is threatened by several other factors, including geopolitical tensions, slow economic growth, and social and environmental concerns. The country's envisioned reliance on gas imports exposes it to global market volatility and geopolitical events, while domestic production is constrained by technical, infrastructure, financial, litigations and economic challenges. South Africa has already felt the tangible effect on gas availability of civil unrest in Mozambique, which exposed highlighting the vulnerability of South Africa's reliance on imported gas.

1.5 Research Aim and Objectives

Aims

This study aims to evaluate strategies that can assist South Africa to achieve sustainable security of gas supply as a transitional energy source. A balanced between economic growth, social impact and environmental factors is sought.

Objectives

a) To evaluate the sustainability and security of existing sources of gas supply, with consideration of socio-economic and environmental factors.

b) To assess the current state of technological developments, gas supply infrastructure, including production, importation, transportation and distribution facilities.

c) To examine the policy and regulatory framework governing the gas sector and its alignment with the country's energy transition goals.

d) To explore opportunities for regional cooperation and diversification of gas supply sources.

e) To evaluate the importance of public-private sector cooperation to achieve effective and reliable energy supply in the country.

1.6 Research Questions

The following research questions are fundamental to this study and are in line with the aims and objectives stated above. `

Research Question 1

What are the key factors influencing current and future security of gas supply in South Africa?

Research Question 2

How do technical and infrastructure constraints affect the sustainable security of gas supply in South Africa?

Research Question 3

What strategies can be deployed to improve the sustainable security of gas supply in South Africa, and what are their potential effects on the energy transition?

Research Question 4

How crucial is the collaboration between public and private sector to ensure sustainable security of gas supply?

1.7 Research Propositions

The sustainable security of the supply of gas as a transition energy tool requires a strategic balance between energy security, economic development and environmental sustainability. Below are key propositions to support sustainable gas supply in South Africa.

Propositions 1

Diversification of sources of gas supply. Increased investment in both domestic and imported gas supply to improve sustainability and security of gas supply in South Africa, thereby reducing dependence on coal for electricity generation.

Proposition 2

Infrastructure development and technological advancement: Expand, maintain and repurpose infrastructure to facilitate gas supply. Gas infrastructure remains the biggest enabler to a sustainable gas market.

Proposition 3

Policy and regulatory framework – Laws and regulations that are internally consistent and aligned with long term national energy transition objectives.

Proposition 4

Public-private cooperation: Fostering meaningful cooperation between the public and private sectors in the gas supply chain.

1.8 Significance of the study

As the country transitions to clean energy regime and achieving its commitment to net-zero carbon emission by 2050, it must do so in a sustainable manner, balancing

economic development, energy security and environmental sustainability, as is articulated in a Just Energy Transition. The World Economic Forum (WEF) frames an effective energy transition as “A timely transition towards a more inclusive, sustainable, affordable and secure energy system that provides solutions to global energy-related challenges while creating value for business and society, without compromising the balance of the energy.

The essence of the study is to contribute to a better understanding of how South Africa can transition without undermining long term decarbonisation goals energy justice principles and socio-economic development goals.

1.9 Delimitations of the Study

The security of gas supply is multifaceted and has both challenges and opportunities; therefore, this study focuses on energy security, sustainability, and socio-economic input rather than having a broader scope. Several delimitations were intentionally established to keep the researcher focused.

a) **The role of gas as a transition energy:** the research is deliberate in considering gas as a transition energy and not assessing gas as a permanent solution or as a replacement for coal or renewable energy, but evaluates its role as supplementing these energy sources.

b) **The analytical framework:** the study uses energy security and sustainability, focusing on environmental, socio-economic and supply stability aspects of gas.

c) **Time frame:** the study focuses on developments in the medium term, aligning with South Africa’s transition targets and planned infrastructure developments.

d) **The role of policymakers, energy providers, and industry players in achieving reliable gas supply:** while comparative reference may be made to labour, no detailed analysis of the role of labour as the South Africa transitions to cleaner energy sources and technological advancement has been undertaken.

e) **Participants** have been deemed neutral and unbiased.

f) **Methodology and data sources:** the research is based on secondary data, government policy documents, academic literature, industry reports, and publicly

available information such as newspaper reports. Primary data collection such as interviews was limited to industry players with in-depth knowledge of the sector.

1.10 Assumptions

The study is underpinned by the following key assumptions to help establish baseline scenarios, clarify uncertainties and develop a framework on sustainability and security of gas supply.

a) Development of indigenous gas supply to meet domestic demand.

b) Infrastructure and technological advancement to support domestic gas and gas imports.

c) Regional integration and cooperation with neighbouring countries.

d) Policy and regulatory framework.

e) Enhanced private sector participation.

Table 1.1: Definitions used in this study

Terms are defined in the table following.

TERMS	DEFINITIONS
Gas: natural gas (NG); liquefied gas (LNG), compressed gas (CNG), liquid petroleum gas (LPG).	The Gas Act (No 48 of 2001) describes gas as all hydrocarbon gases transported by pipeline, including gas, artificial gas, hydrogen-rich gas, methane-rich gas, synthetic gas, coalbed methane gas, liquefied gas, compressed gas, re-gasification of liquefied gas, liquefied petroleum gas, or any combination thereof. **Liquefied natural gas (LNG):** is gas in its liquid form. LNG is gas cooled to minus 260 degrees Fahrenheit to liquefy it, which reduces its volume, enabling suppliers to land cargoes in the highest-priced markets. LNG is shipped. Liquefaction and shipping form the largest portion of the LNG supply chain costs, while regasification is the least of any of the cost components (Energy Primer, 2020). **Compressed gas (CNG):** is a gas that has been compressed to less than 1% of its volume, at standard atmospheric pressure. **Liquified petroleum gas (LPG):** is a hydrocarbon gas that is stored in a liquid form under pressure. It consists mainly of propane, butane, or a mixture of the two often produced as a byproduct of gas processing during the refining of crude oil.
Gas infrastructure	— Refers to the supporting infrastructure that facilitates the development, transmission and storage of gas, such as transmission pipelines, floating storage and regasification facilities, etc. — LNG import and regasification facilities. — Storage facilities. — Gas infrastructure includes modern technology, and LNG infrastructure. — Pipelines (domestic and cross border). — Green infrastructure carbon capture technology.
Net zero carbon emission	Refers to a future where carbon emissions are balanced with carbon removal (carbon released = carbon captured or removed) and/or carbon offsetting (a reduction in carbon emissions to compensate for emissions generated elsewhere).
Policy uncertainty	Refers to continual changes in policy environment such that it created uncertainty amongst stakeholders.

Renewable energy sources and technologies	Solar, wind and battery storage facilities.
Renewable energy	Energy that comes from resources which are naturally replenished on a human timescale, such as sunlight, wind, water, tides, waves and geothermal heat.
Security of gas supply	Development and facilitation of gas supply to meet demand
Sustainability	"Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987).
Southern Africa (SADC)	Southern Africa consists of South Africa, Namibia, Botswana, Lesotho, Swaziland, Zimbabwe and Mozambique.

1.11 The Structure of the Report

The structure of this research study is as follows:

Chapter 1: Introduction.

Chapter 2: Literature review.

Chapter 3: Research methodology.

Chapter 4: Research findings.

Chapter 5: Analysis of findings and results.

Chapter 6: Conclusion.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

In this chapter, existing research, policies, and scholarly articles relating to energy security supply are reviewed, with emphasis on security of gas supply, as gas is recognized as a cleaner-burning alternative to coal and oil, as it emits less CO_2.

This chapter further covers the concept of energy security; gas as a transition energy source; strategic imperatives to enable South Africa to achieve sustainable security of gas supply, which are: *the domestic gas market*, *regional integration*, *infrastructure and technological advancement*; *policy and regulatory framework*; and *public and private sector cooperation*. The interplay among these strategic imperatives forms the basis of this study. Lastly, case studies of five countries that have adopted gas as a transition energy will be reviewed, to identify lessons for South Africa.

2.2 The concept of energy security

The most frequently quoted definition of energy security is the “availability of sufficient supply at affordable prices” (Yergin, 2006). Furthermore, Yergin alludes to energy security as a fundamental imperative for countries as energy undergirds economies and is essential for the well-being of populations. Although muted during the COVID-19 pandemic, its salience has reemerged with a new urgency. Today, energy security assures the availability of reliable and affordable supplies; encompasses both conventional oil and gas and renewables as well as electric grid reliability. The engine of energy security is investment in supplies and infrastructure needed to meet increasing demand (www.spglobal.com).

Energy security refers to the reliable availability of affordable energy supply to meet the demand of a country, continuously. IEA (2022) describes energy security as not just about having uninterrupted access to energy, but also about securing energy supplies at affordable prices. It encompasses a broad range of social, economic and environmental factors.

Academic literature recognizes the diverse interpretation of the concept. Daniel et al. (2015) describe energy security as multidimensional, incorporating security of supply, security of demand, affordability, geopolitical considerations, defence policies, other

political risk factors, economic risk factors and energy poverty, including technological and environmental risk factors.

Cherp (2011) and Cherp and Jewell (2014) note that energy supply has been researched by various authors, and although there is no consensus on a single definition, it remains a matter of great importance for all societies. Accordingly, energy security should be examined through the “four A’s” approach: Availability, Accessibility, Affordability and Acceptability.

In the context of South Africa, energy security should indeed encompass accessibility, affordability and availability. As the World Energy Council (2019) states, what countries and stakeholders understand and mean by “energy security” is evolving and will continue to change as the energy transition progresses.

2.3 Gas as a transition energy source

There are differing opinions on the role of gas as a transition energy in South Africa. Support for gas is based on the significance of gas in ensuring energy security, particularly in transitioning to a low-carbon economy. Some researchers agree on the importance of gas in energy security for its abundance and availability as an emerging energy, its energy density and versatility, its low carbon footprint, and its ability to become a bridging fuel in an energy transition.

Gas can be easily stored and transported, making it a reliable energy source for baseload electricity generation and peak demand management. It is a strategic energy with geopolitical significance, which will reduce dependence on imports. Most importantly it can contribute to a more diversified, reliable, and sustainable energy mix, while also supporting economic growth and development. Biresselioglu et al. (2015), Devaraj et al. (2021), and Kim et al. (2024) emphasize the need for diversifying gas sources to improve the security of supply.

In South Africa, diversification is particularly crucial due to its limited domestic production, reliance on imported gas, and exposure to global market fluctuations, geopolitics, etc. Aksyutin et al. (2020) and Kim et al. (2024) highlight the role of gas in achieving the United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), and its being a reliable and efficient source of

energy for electricity generation, industrial processes, and transport, thereby increasing energy access, and reducing reliance on coal.

While some argue differently, Graczyk et al. (2023) and Kim et al. (2024) acknowledge the environmental implications of using gas and the need for sustainable energy management. The use of gas has significant environmental implications in the long run, including methane emissions, air pollution, and water contamination, which necessitate sustainable energy management. While gas is a cleaner-burning fuel than coal and oil since it emits less CO_2; its production, transportation, and combustion still pose environmental risks. In South Africa, the increasing reliance on gas for electricity generation and industrial processes amplifies these concerns.

However, disagreements arise on how to achieve sustainable gas supply security. The Industrial Gas Users Association of Southern Africa (IGUA-SA) (2024) focuses on increasing gas production and infrastructure development, and advocates for a more robust gas supply chain. In contrast, Halsey et al. (2022) suggest transitioning to cleaner energy sources to reduce dependence on gas and mitigate climate change effects. The CSIR (2023) proposes a more circular energy sector, emphasizing energy efficiency, waste reduction, and recycling to minimize the environmental footprint of using gas. These differing views reflect fundamental disagreements on the role of gas in the energy transition, with IGUA-SA prioritizing gas production and Halsey et al. and the CSIR advocating a more diversified energy mix.

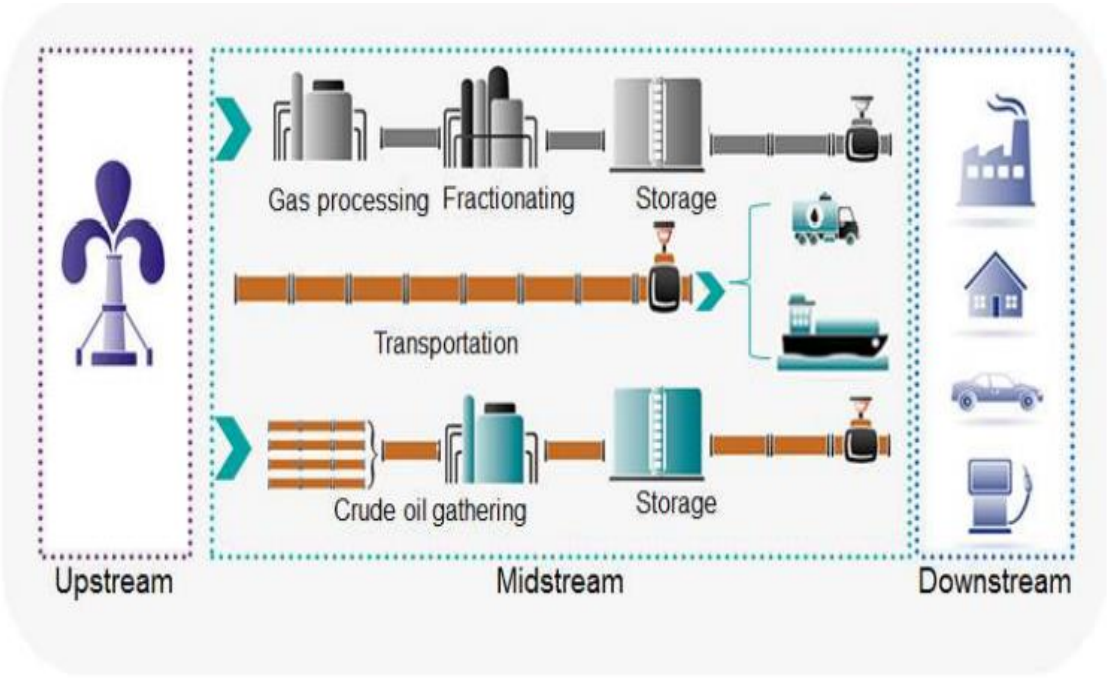
Areas of disagreement noted among scholars may be due to different methodological approaches, ranging from qualitative analysis (Biresselioglu et al., 2015) to quantitative models (Devaraj et al., 2021) to case studies (Graczyk et al., 2023) in exploring sustainable gas energy security in various jurisdictions. Studies focus on different regions, including global perspectives (Aksyutin et al., 2020), specific countries (Graczyk et al., 2023), and regional analyses (Kim et al., 2024). While numerous scholars acknowledge the importance of energy security, they prioritize different dimensions, such as supply security (Biresselioglu et al., 2015), sustainability (Aksyutin et al., 2020), and environmental concerns (Graczyk et al., 2023). Kim et al. (2024) emphasize the need for a green transition, potentially reducing the role of gas, whereas Aksyutin et al. (2020) see gas as a crucial part of achieving the SDGs.

2.4 Domestic Gas Market

Gas-fuelled dispatchable generation is one of the main tools many countries are using to facilitate the transition to renewable-based grids. In South Africa, the IRP 2019 process has assumed that gas-fuelled generation would be part of any transition. However, the source of gas and the steps to utilize gas have not been detailed in any version of the IRP and are still an open question (Clark, 2020). The IRP 2019 contends it is characterized by fast changes and uncertainties regarding the effect of technological changes on future energy provision systems. It warns of uncertainties and cautions of future commitments. Significantly, critics of IRP 2019 point to the absence of certainty and predictability this brings to the sector. The following section looks at the gas value chain, as the entire value chain is interlinked. Thereafter potential gas resources, including cooperation with neighbouring countries, are discussed.

Gas Value Chain

The gas industry has three main segments: the upstream (supply), the midstream (transportation), and the downstream (consumption). The upstream segment includes the exploration and development of gas resources and reserves, and its production. The midstream segment includes transportation on pipelines that move gas through large-diameter pipelines to storage facilities and a variety of consumers. The downstream segment includes large gas consumers, such as power plants and industrial facilities, and local distribution companies, which deliver gas to retail consumers (Energy Primer, 2020). Figure 1 is a pictorial depiction of the gas value chain.



SOURCE: Alerian Energy Infrastructure Portfolio

Figure 2.1: Gas Value Chain

Potential Sources of Gas

Globally, gas demand for electricity generation has expanded considerably over the past decade and is likely to continue to increase in the coming years. Power plants' demand for gas reflects lower gas prices, the operating flexibility of gas-fired generators, and the environmental benefits of the fuel. Gas-fired power plants emit less air pollution than power plants using coal or oil (Energy Primer, 2020).

The South African gas market faces possible supply shortages, with looming gas depletion in Mozambique, as reported by Sasol Gas. Domestic gas production is currently limited to Renergen (Tetra 4), which has been producing small quantities of helium gas for the compressed gas market and liquefied gas for industrial customers as part of its initial phase (Energy Primer, 2020).

The reported gas discoveries in various parts of South Africa have various challenges such as lack of infrastructure, regulatory uncertainty, opposition from environmental activists and uncertain economic feasibility.

TotalEnergies (Total) announced gas condensate discoveries off the southern coast of South Africa in the Brulpadda Block, gas fields covering 19 000 square kilometres under the Indian Ocean between George and Jeffreys Bay. Total and its partners began

drilling in December 2018. The gas reserve is more than 3 600 metres deep. At that point Total predicted that the gas fields could yield up to one billion barrels of gas. The reserve of gas condensate contains small traces of oil, meaning it is a wet gas, which could be converted into petrol at a gas-to-fuel refinery in Mossel Bay. The gas could also be used as a coal alternative in generating electricity (www.averda.com).

Reuters reports exploration and development activities in Namibia and South Africa has attracted investment from several multinational companies such as TotalEnergies, Shell and Chevron. These exploration and development activities are of long-term nature with no short to medium benefit to South Africa. The impending gas shortfall remains a challenge for the country.

Liquified Gas (LNG)

According to the Norton Rose Fulbright website, Mozambique will be the second-largest LNG producer in Africa after the completion of various ongoing projects, and it has the potential to become the third-largest global LNG exporter after Qatar and Australia. Mozambique's Matola Gas Company, in partnership with Total, recently announced the construction of an LNG terminal in Mozambique's Port of Matola. It has been reported that LNG will initially be imported from the international market and will later be replaced by LNG produced from gas reserves in Mozambique's Rovuma Basin (https://www.nortonrosefulbright.com).

The growing availability of LNG puts gas at the disposal of countries with limited access to pipeline gas, such as South Africa, and therefore projected LNG prices are now a major determinant of uptake, rather than the availability of gas resources, since LNG can be procured globally (Energy Primer, 2020).

On the other hand, the South African government has announced plans to develop the following LNG import terminals:

- Coega Special Economic Zone (and the adjacent port of Ngqura) situated in the Eastern Cape for the development of the nation's first LNG import terminal, and a new gas-to-electricity plant. Creative technical solutions will be required to utilize the port, as there is a risk of traffic congestion and related challenges due to difficult sea conditions outside the port.

- Saldanha Bay LNG Terminal: located on the west coast of South Africa, selected to facilitate energy supply for industrial users in the region; and
- Richards Bay in KwaZulu-Natal, earmarked as the leading LNG, aimed at enhancing energy security and transitioning to cleaner energy sources. Development of floating storage regasification unit (FSRU) facilities.

Eskom and Sasol's LNG exploration was announced in September 2024, an agreement to explore the use of LNG for energy generation to facilitate transitioning to cleaner sources of energy.

Shale Gas

The existence of shale gas reserves has been in the news and has become a topic of debate between policy makers and environmentalist groups for a long time in South Africa. The existence of local shale gas in the Karoo has been proven, as shown by the Soekor test wells, although the feasibility in terms of development costs, and commercial viability of volumes is still unknown at this stage (Rosewarne, 2014). The Karoo Basin is estimated to have 30-500 trillion cubic feet (Tcf) of shale gas, but actual reserves remain unknown more drilling is conducted. While there might be some exploration efforts continuing in the shale gas areas in South Africa, the probable timing and cost of this potential gas development minimises its usefulness for consideration in planning for gas dispatchable electricity. Analysis of potential development and production costs for this gas indicates that it is unlikely to be competitive with other fuel alternatives (Clark et al., 2021). The comparative likely cost of developing Brulpadda and Orange Basin gas has decreased the attractiveness of shale gas in South Africa (Clark et al., 2019).

In summary, there are notable strides in advancing gas exploration and production, both offshore and onshore. TotalEnergies sought environmental authorization to drill up to seven exploration wells in the southern part of the Deep-Water Orange Basin off South Africa's west coast, signalling a renewed commitment to its hydrocarbon potential. As of February 2025, the environmental authorization was granted, and TotalEnergies was preparing to commence drilling operations by mid-2025. This development aligns with the country's strategy to attract major international oil companies and explore the Orange Basin, which has seen significant discoveries in

neighbouring Namibia. If successful, these wells could transform South Africa's energy landscape to become self-reliant, and a key player in the region.

There are other developments of a small but significant nature in exploration and development in Mpumalanga. If successful, this could compete in gas for electricity generation and industrial use to reduce the current energy costs and support the country's transition to cleaner energy sources.

2.5 Regional Integration

South Africa’s immediate neighbours, Namibia and Mozambique, also have gas fields which are still under development, while Mozambique is in a commercialization phase. The offshore Kudu field, about 180 km west of the Namibian coast, has reserves of about 1.5 Tcf. Angola has two inland fields at Pande-Teman, with combined reserves of about 3 Tcf. An 895 km pipeline is now being built which will bring gas from Teman in Angola to Secunda in South Africa, where it will join the existing pipeline system that links Gauteng province to the urban areas of Durban and Secunda. The pipeline started delivering gas in early 2004 (DMRE 2022).

The United Nations Economic Commission commends regional integration as a key strategy for advancing Africa’s socio-economic endeavours, by way of unification of nations, benefits from large economies of scale, and increased levels of investment and trade.

Gas production and exploration are dominated by foreign companies such as TotalEnergies, Shell, and Qatar Energies, because Southern African companies lack the requisite financial muscle to pursue production and development. Alternatively, effective beneficiation policies that will empower regional development must be vigorously followed. Examples are countries like Norway and Brazil, where their mineral endowments advanced their own economies through beneficiation policies.

Equally, for example, when China experienced rapid economic growth and could not satisfy its excessive energy demand, it explored and expanded international energy imports to ensure the security of its energy supply (Lifan Li, 2016). This is not the case with African countries; exploration and development activities are dominated by foreign

multinational companies, who make huge profits they repatriate to their own countries, only benefiting a few politicians.

Currently, there is limited intra-Africa trade in energy. Only 1.8% of the continent's oil exports go to other African countries. LNG trade from Algeria, Egypt, Equatorial Guinea, Libya, and Nigeria is destined for countries in North America, Europe, and Asia/Pacific (Cherp, 2011; Cherp & Jewell, 2014).

South Africa must strengthen its bilateral relationships with its SADC neighbours to ensure that it secures gas sources.

2.6 Infrastructure and Technological Advancement

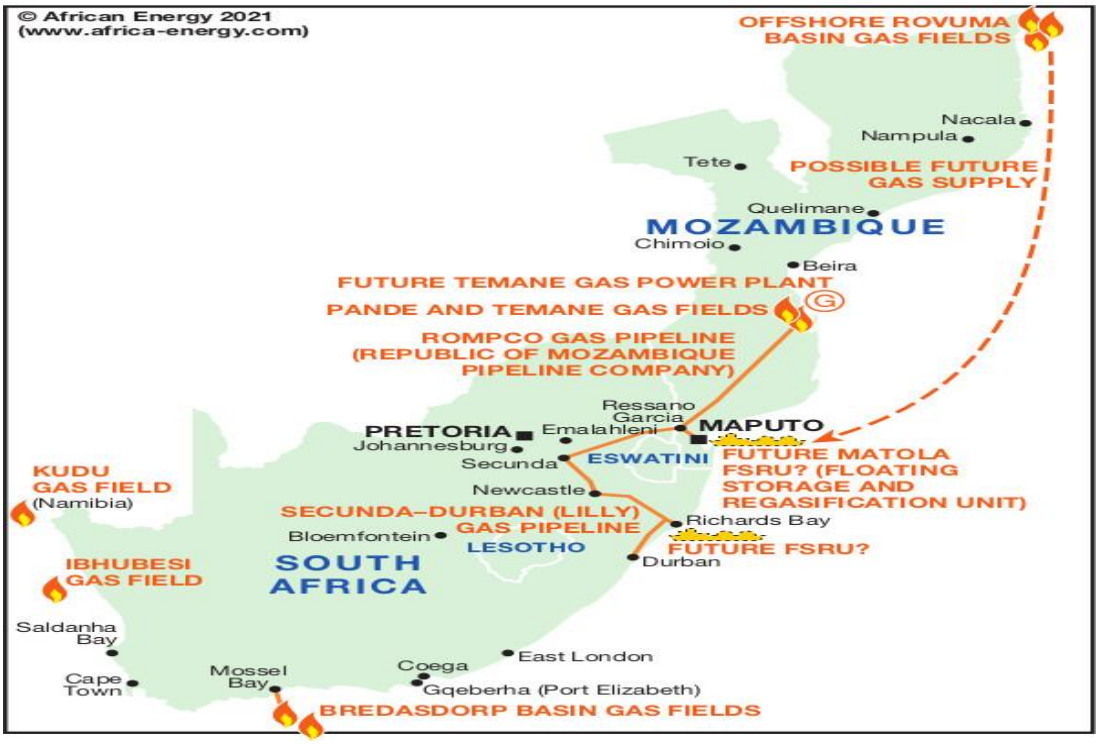
The aim of the Infrastructure Development Act (Act 23 of 2014) is to facilitate and co-ordinate public infrastructure development that is of significant economic or social importance to South Africa. This is to ensure that infrastructure development in the Republic is given priority in planning, approval, and implementation; and to ensure that the development goals of the state are promoted through infrastructure development. This is further to improve the management of such infrastructure during all life-cycle phases.

Sustainable gas supply cannot be realized without enabling gas infrastructure, such as pipelines, gas containers, and storage facilities traversing from exploration to end usage. The SADC region has an underdeveloped infrastructure network, leading to limited trade opportunities and facilitation of domestic and regional orderly development of gas.

South Africa has a developed electricity network and one of the highest rates of electricity access in sub-Saharan Africa (IEA, 2020). However, it must continue to maintain and upgrade the existing infrastructure and modify it for renewable energy sources. The emphasis is on the country to prioritise infrastructure development, including modernizing and maintenance of existing infrastructure to be aligned with the future developments in the energy industry. Since the adoption of the National Development Plan (NDP) in 2012, there have been unprecedented changes in the relative costs of electricity generation technologies in the electricity sector with effects on other energy carriers. Accordingly, a comparison of technology costs between when

the NDP was adopted and the current period provides a notable illustration of how quickly the energy sector is changing (NDP, 2030). The lack of appropriate technologies has hampered diversification into renewables such as solar, wind, and small hydro (Cherp, 2011; Cherp & Jewell, 2014).

There are different views on investing in gas infrastructure. Because gas is viewed as a short-term measure, it will be uneconomical to invest in long-term infrastructure for short-term solutions, which will result in stranded assets. Currently, the ROMPCO pipeline is the only cross-border gas pipeline. Further developments might be needed if gas is secured from Mozambique. Figure 3 below shows the pipeline from Mozambique to South Africa.



SOURCE: ww.africa-energy.com

Figure 2.2: Cross border gas pipeline network

2.7 Policy and Regulatory Framework

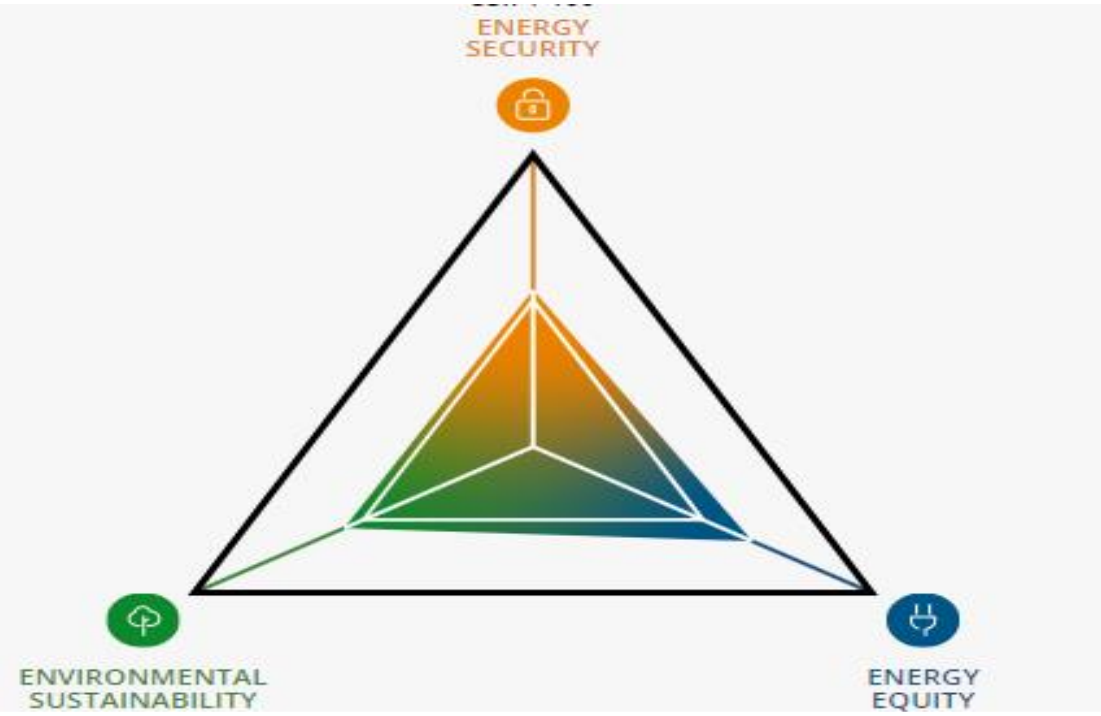
This section covers the energy policy and regulatory framework of the energy sector in general. In this context, a coherent policy framework, implementation of policies and political will are fundamental to a successful policy implementation. Incoherent policy framework results in policy failures by making it impossible to provide goals or deliver them due to organisational problems such as processes or governance. For example,

consider two institutions such as a Ministry of Climate (manages climate policy) and a Ministry of Energy (manages energy affairs), fighting for the superiority of their policies. This could result in a non-coherent policy being adopted due to a lack of coordination, and fewer benefits to society from the energy sector. Naturally, the same situation may occur in South Africa if there is no relevant agency established (e.g. due to budget constraints or lack of relevant human resources).

Even the best targets cannot be fully realized if they are not monitored due to a lack of policy framework. For instance, when left alone the goals for 100% renewables in the energy mix or 2050 carbon neutrality can drift onto rocks of incoordination. The same concerns correcting the end-use energy injustice, which requires improved energy poverty detection and monitoring frameworks (Bouzarovski & Simcock, 2017; Sokołowski & Heffron,2 022).

Likewise, Bellos (2018) argues governments around the world are called on to guide their respective energy production and consumption to solve several challenges, yet such calls can only bear fruit if they are based on a holistic understanding of national energy transitions that involve energy flows and markets, energy technologies, and energy policies. These co-evolve in three distinct systems: techno-economic, socio-technical, and systems of political actions (Cherp et al., 2018). As important as these discussions are, at least two important aspects are missing: a developmental perspective, and a measurement framework for managing policy trade-offs between the status quo and a desired transition state (Bellos, 2018).

The figure below demonstrates the triangulation in energy transition, balancing economic growth, environmental sustainability, and social equity. It is important to balance the country's developmental objectives, with climate commitments and ensure social equity.



SOURCE: https://www.worldenergy.org/publications

Figure 2.3: Policy Linkages

Prior to 1994, the state had invested heavily in the energy sector. Often these investments had been uneconomic, and the sector had operated in conditions of secrecy imposed by legislation, and levels of accountability and transparency were problematic. The major South African energy markets were non-competitive, controlled by large monopolistic energy enterprises, and heavily regulated non-competitive regimes. It is to be expected that reforms of the sector which would per force take on large influential and powerful actors in the South African economy, would face significant challenges (Trollip, 2007).

White Paper on Energy Policy of 1998

The White Paper on Energy Policy is the foundation of South Africa's energy policy. It guides the transformation of the energy sector, addressing access to energy, sustainability and economic development. Further, it outlines a comprehensive strategy for the development and management of the energy sector, covering various forms of energy: electricity, coal, oil, gas, and renewable energy. The objectives of the white paper are to ensure energy access and equity, energy efficiency, economic growth and competitiveness, environmental sustainability, energy security,

restructuring and regulation of the energy sector (Energy White Paper, 1998). The white paper views gas as an attractive option; and recognizes the government's commitment to develop the industry, thus ensuring a stable policy environment and harmonization of regional policies and bilateral agreements.

National Development Plan (NDP, 2030)

The NDP envisages that by 2030 South Africa will have an energy sector that provides reliable and efficient energy services at competitive rates; socially equitable through expanded access to affordable energy and environmentally sustainable, at reduced emission and pollution levels.

The NDP sets the role of gas as a bridge energy source, as the country transitions from coal-fired electricity to cleaner sources of energy. The development of domestic gas resources and the importation of liquified gas is outlined. Gas is to be integrated into the diversified energy mix as the reserve fuel that supplement intermittent renewable energies. In addition, development of gas infrastructure such as gas pipelines and storage facilities are also outlined, including investment in gas-to-electricity projects and gas-based hubs.

Critics of the NDP such as Meridian Economics (2022) say it is outdated. They note that in the ten years since the NDP was published there has been unprecedented change in both the cost of clean energy alternatives, and the global decarbonisation imperative. They say the new generation capacity should be wind and solar, and reject the large-scale use of gas envisaged in the NDP.

Integrated Resources Plan (IRP 2019)

The IRP is a long-term electricity infrastructure development plan. The IRP 2010 introduced renewable sources responding to climate change requirements of reducing carbon emissions. It has since been updated with IRP 2019. A draft IRP 2023 was published in the *Government Gazette* for public comment in December 2023. The IRP has set ambitious targets for gas-to-electricity, which increased the role of gas in electricity generation. The draft IRP 2023 increased the allocation of gas-to-electricity to 6220 MW, from 3000 MW allocated in the IRP 2019.

In November 2024, the Department of Electricity and Energy released IRP 2024 for public comment. Its key assumptions and goals include an increase in the assumed energy availability factor of Eskom's coal fleet, committed capacity additions by 2030, renewable energy focus, gas-to-electricity allocations, demand growth, revised decommissioning of ageing coal-fired plants and grid infrastructure. Gas-to-electricity also continues to feature heavily in the generation mix, as in the IRP 2023.

Gas Master Plan (GMP) 2024

The Gas Master Plan's 2024 objective is to integrate gas into the energy mix to enhance the security of the gas supply of South Africa. The future role of gas depends on a range of factors, such as the development of the domestic gas market, infrastructure investment and technologies, the pace of renewable energy growth, declines in coal, rates of end-use electrification, the industry's record on methane abatement, and growth in low-emissions gases (IEA, 2023).

The GMP outlines various scenarios that will integrate gas in a diversified energy mix. The baseline scenario: matching medium gas demand growth in gas and supply from short-term gas fields. The indigenous gas supply scenario: gas demand is assumed to be lower and can be met from indigenous gas fields as opposed to imports. The regional integration scenario: priority is given to gas supply from Mozambique, Namibia, etc, rather than established markets. Gas as a transitioning fuel scenario: expected higher growth in gas demand, which includes global and regional sources and LNG imports from established markets. These scenarios aim to ensure a diversified and security of supply, balancing domestic production with imports.

Critics of Gas Master Plan 2024

Critics of the Gas Master plan cite several shortfalls, such as failure to provide an immediate solution to the looming gas crisis facing the country. Clark et al. (2022) highlight the failure to make progress. Little has been achieved since the first published draft in 2015, when the first iterations were issued for preliminary comments. This was followed by an updated version that incorporated comments on gaps in the IRP 2019.

In addition, critics say the Gas Master Plan's assumptions are based on the outdated data of the National Planning Commission's 2012 NDP, which promotes gas as a viable alternative to coal. The sector has since evolved, with new developments in both gas

technology and other clean energy alternatives in the global renewable energy market (Meridian Economics, 2022).

The Gas Act, 48 of 2001

The Gas Act, 48 of 2001, provides the legal framework for regulating the gas industry in South Africa. The act outlines the rules for the development of the sector, and for distribution, storage, transmission, and trading of gas. In addition, the act aims to facilitate investment in and orderly development of a piped gas industry. The act's objectives include promoting efficient, effective, sustainable, and orderly development and operation of gas transmission, storage, distribution, liquefaction, and regasification facilities (Gas Act, 48 of 2001).

2.8 Public-Private Sector Cooperation

This section looks at measures to encourage improved public-private collaboration; both parties have a role to play. Energy is a key element of the modern economy but is undergoing unprecedented change. The geopolitical landscape of energy is shifting, and environmental concerns have shaken the system's foundations. At the same time, the economics of competing energy sources have changed, and the advent of Fourth Industrial Revolution technologies have enabled new business models and made others obsolete. The diverse challenges facing the energy system today cannot be addressed by a single government, industry, company or other institution alone.

Governments have important responsibilities in reforming the electricity markets. They must decide on the relative roles of public and private sectors in providing electricity services, the governance and reform of public enterprises operating in the market, and the new structure of electricity supply arrangements to introduce competition where feasible. This includes unbundling and the development of electricity markets. Reform of the governance and regulatory arrangements is needed to improve oversight of the electricity market and introduce incentives for service providers to be efficient and responsive to consumer needs. They should also incorporate priorities for access, equity, and environment in the policy framework (jbesantjones@worldbank.org)

Policies are needed to entice private capital, including public-private partnerships, to share costs and risks and to build capacity in local financial sectors to increase access to loans and other forms of financing (IRENA, 2015). The gas industry can consider

the lessons learned from the electricity sector about opening the market by strengthening policies and regulation for the gas industry, which might increase interest in the industry. Countries like the United States developed their gas market through policy frameworks that liberalized and supported the gas industry.

The evolving energy landscape, characterised by geopolitical shifts and technological advancements, presents both challenges and opportunities for Africa. Stakeholders in the energy sector have highlighted the need for investment in infrastructure and technology to enhance grid efficiency, energy storage, and resilience. Hence collaboration between public-private partnerships, and regulatory reforms have become more crucial (Africa Energy Review Report, 2024).

2.9 Benchmarking

This section benchmarks South Africa against gas transition in five countries: two developed economies (namely Norway and the UK), two partners from BRICS (Brazil, Russia, India, China, and South Africa), and Kenya. The countries chosen are a mix of those that have transitioned to renewable energy and those, like South Africa, heavily reliant on coal for electricity generation. The percentage of gas used for electricity generation varies by region and by country, but the IEA indicates that globally about 40% of gas consumption is used for electricity generation.

Table 2.1: Benchmark gas transitions

COUNTRY	BRIEF OVERVIEW
Brazil	Brazil has one of the cleanest electricity grids globally. Its energy mix is 85% renewables (hydropower, wind and solar). Gas is about 8%-10% of electricity generation, but plays the role of reserve energy, especially in the dry season when hydro output has dropped.
China	China is a member of BRICS and an important trading partner. South Africa and China both depend heavily on coal, but China is progressing faster in renewable energy and gas as a transition energy. About 18% of its electricity generated via gas. China has the world's largest LNG import capacity, extensive gas pipelines, and a growing domestic gas market.
Kenya	Kenya’s gas consumption is minimal, due to lack of domestic gas production and infrastructure. There is no reported gas-fired power

	station in the country. Gas plays a minimal role in the country's energy landscape.
Norway	Norway is different from South Africa in its gas landscape. It generates 90% of its electricity from hydropower, and its gas consumption is minimal, accounting for just 1% of its total energy consumption. The country is the second largest gas exporter to Europe, but uses very little domestic domestically.
United Kingdom (UK)	The UK's energy mix consists of 40% renewables (wind, solar and biomass), with gas being the single biggest source of electricity generation, accounting for 38%, nuclear 15%, and coal 1%. In South Africa on the other hand, coal accounts for up to 70% of electricity generation, gas 3% contribution to the total energy mix, and nuclear 1%. The balance can be attributed to renewable energy sources.

Table 2.2: Consistency table: Research questions and propositions

RQ #	State research question or objective	State proposition or hypothesis
1	**Research Question 1** What are the key factors influencing the current and future security of gas supply in South Africa?	**Proposition 1** Diversification of gas supply sources. Increased investment in both domestic and imported gas supply to improve sustainable security of gas supply in South Africa, thereby reducing dependence on coal for electricity generation.
2	**Research Question 2** How do technical and infrastructure constraints affect the sustainable security of gas supply in South Africa?	**Proposition 2 Infrastructure development and technological advancement:** Expand, maintain and repurpose infrastructure to facilitate gas supply. Gas infrastructure remains the biggest enabler to a sustainable gas market.
3	**Research Question 3** What strategies can be deployed to improve the sustainable security of gas supply in South Africa, and what are their potential effects on the energy transition?	**Proposition 3 Policy and regulatory framework** Laws and regulations that are internally consistent and aligned with long term national energy transition objectives.
4	How crucial is the collaboration between public and private sector to ensure sustainable security of gas supply?	**Proposition 4 Public-private sector cooperation**. Fostering meaningful cooperation between the public and private sectors in the gas supply chain

2.10 Conclusion of Literature Review

Multiple dimensions of energy security were reviewed. The emphasis was on the domestic gas market, regional cooperation, the policy and regulatory framework, infrastructure development, public-private sector cooperation, and benchmarking other countries.

Energy security can be understood as the availability of sufficient supply at affordable prices. Thus, energy security refers to the reliable availability of affordable energy supply to meet the demand of a country, continuously. The IEA (2022) describes energy security as not just about having uninterrupted access to energy, but also about securing energy supplies at affordable prices, encompassing a broad range of social, economic and environmental factors.

In this context, energy security focuses on the availability of gas as part of the energy mix while South Africa transitions towards renewable energy sources. Gas is expected to play a pivotal role as a transition energy for several reasons, including its abundance and availability as an emerging energy, its energy density and versatility, its low carbon footprint, and its ability to become a bridging fuel in energy transition. Gas can also be easily stored and transported, making it a reliable energy source for baseload electricity generation and peak demand management.

There are opposing views on the role of gas. Critics note that gas is, after all, a fossil fuel and burning it emits carbon dioxide. Hence, gas is not universally accepted as a transition fuel in South Africa. South Africa is a gas constrained country, relying on imports from Mozambique to supply about 90% of the industrial gas market.

In South Africa's immediate neighbours, Namibia and Mozambique, developments are predominantly led by multinational companies. Mozambique's gas reserves in Rovuma Basin have attracted investment from global players such as TotalEnergies, ExxonMobil and Eni, which have onshore and offshore LNG facilities. Sasol also has a presence in Mozambique's Inhambane province, in addition to the existing gas activities central processing facility in Temane.

By contrast, Namibia's gas activities are dominated by TotalEnergies, Chevron, Exxon Mobil Shell, QatarEnery and Namibia's state-owned Namcor.

Hence the gas from Mozambique and Namibia might not be destined for South African shores. The South African government should intensify bilateral relations with its counterparts in Mozambique and Namibia in this regard.

Regarding the concept of security of supply, opinions differ. In the context of South Africa and in line with the energy policies of the country, the concept resonates with availability, accessibility, and affordability. Security of supply requires diversification of energy sources. Infrastructure and regional (SADC) integration contribute to security of supply through development of gas infrastructure such as pipelines and storage facilities, although there are different views to the government policy position on this matter. It is also clear that although gas is expected to play a crucial role in the transition to a low-carbon economy, there are other views which will be further integrated as the research progresses.

A coherent policy framework will propel the energy transition. The policy environment should triangulate among the social, economic and environmental factors. The Just Energy Transition is one such framework aimed to guiding the country's energy transition.

Sustainable security of gas supply can be strengthened through a well-regulated and competitive gas market that does not rely heavily on imports, as this exposes the country to risks such as geopolitical events, price instability, economic instability and environmental risk factors.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Introduction

The research philosophy of this study is rooted in a pragmatic approach, which acknowledges the complexity of sustainable security in natural gas supply and focuses on realistic, timely and economically viable options to mitigate gas supply constraints.

Axiologically, this study values both objectivity and subjectivity, recognizing the importance of empirical analysis and stakeholder perspectives in understanding sustainable security. Objectivity is essential in establishing the technical and economic aspects of natural gas supply security, while subjectivity acknowledges the role of social and political factors in shaping sustainable security. This axiological stance enables the study to balance empirical rigor with contextual understanding.

Ontologically, this study adopts a critical realist perspective, assuming that sustainable security is a complex, dynamic reality that encompasses both material and social constructs. This means that security of natural gas supply is not only a technical issue but also a social and political construct, shaped by the interactions and meanings of various stakeholders. By acknowledging the role of social constructs, this study can explore how sustainable security is negotiated and contested among different stakeholders, including policymakers, industry players, and civil society. This ontological stance enables the study to examine the complex interplay between technical, economic, and social factors that influence sustainable security.

Epistemologically, this study employs a mixed-methods approach, combining positivist and interpretivist traditions to generate comprehensive knowledge about sustainable security. Positivism informs the quantitative aspects of the study, which seeks to establish causal relationships and patterns in security of natural gas supply. Interpretivism, on the other hand, guides the qualitative aspects, which aim to understand the meanings and interpretations of stakeholders. By integrating both approaches, this study can triangulate findings, increase validity, and provide a more nuanced understanding of sustainable security. This epistemological stance enables the study to navigate the complex methodological demands of a mixed-methods design, ultimately generating actionable insights for policymakers and industry stakeholders.

3.2 Research approach and design

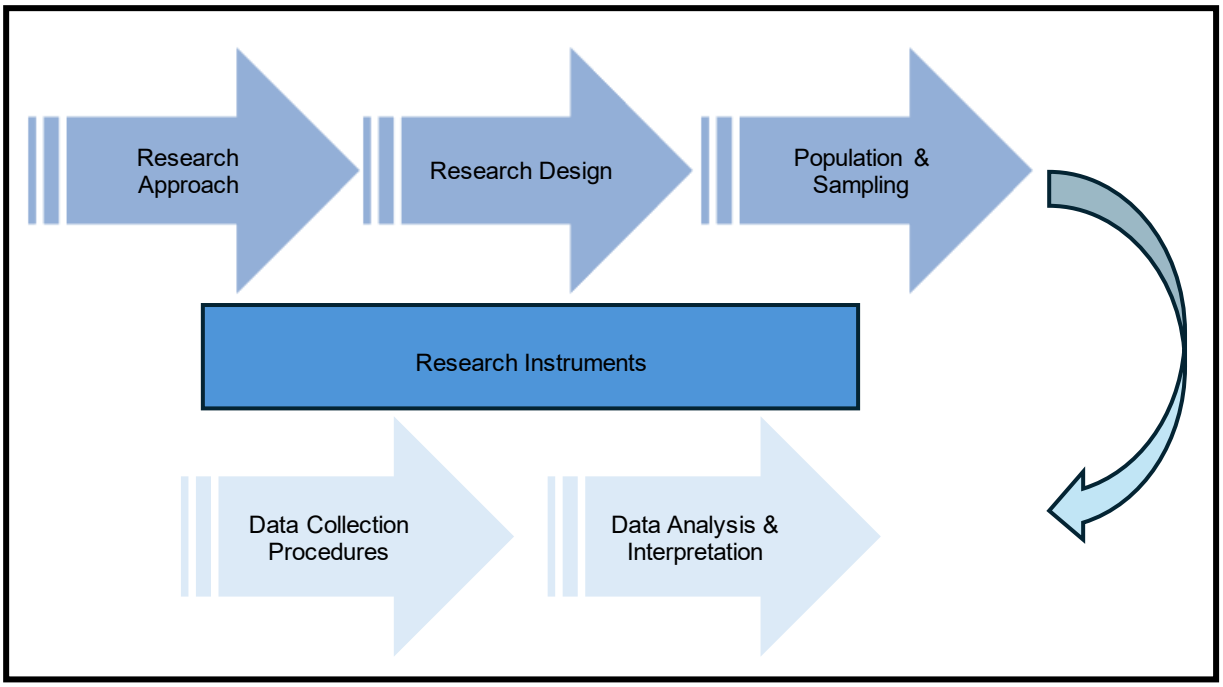


Figure 3.1: Research process

3.3 Population and sample

The population of this study was gas stakeholders in South Africa, across the value chain, of production and exploration, transmission, end-users. Policymakers, regulators, and end-user customers form part of the gas population.

Purposive sampling was employed, where participants were selected at the researcher's discretion, based on their in-depth knowledge of the industry, for semi-structured interviews and surveys.

Snowball sampling was employed, where selection was through referrals by persons who have access to potential participants, such as policymakers, academics and industry players.

The planned sample size was up to 30 participants. Although the intention was to cover five provinces, that was not practically possible as gas users are concentrated in three provinces: Gauteng, Mpumalanga and KwaZulu-Natal. All interviewees were based in Gauteng, which represents most participants in the gas industry.

Interviews were conducted in person, via Microsoft Teams. The interview guide was followed for consistency, while allowing flexibility for more insights. The in-person interview questions were the same as the questionnaires sent out in the survey.

3.4 The research instrument

Data collection entailed both primary and secondary data collection, i.e. surveys by sending questionnaires, interviews, review of existing documents, academic papers, policy documents, newspaper reviews and industry reports, previous research reports, and strategies and case studies from other jurisdictions.

Research instruments used were questionnaires, both in person and in the survey. Questionnaires were sent and responded to via Google link questionnaire. Those who could not access the link were interviewed through Microsoft Teams meetings, and the interviews were recorded.

Participants were encouraged to share their experiences, opinions and ideas, hence the use of open-ended questionaries.

Case studies of countries drawn from developed, middle-income and African countries were reviewed and analysed to identify best practices and lessons for South Africa.

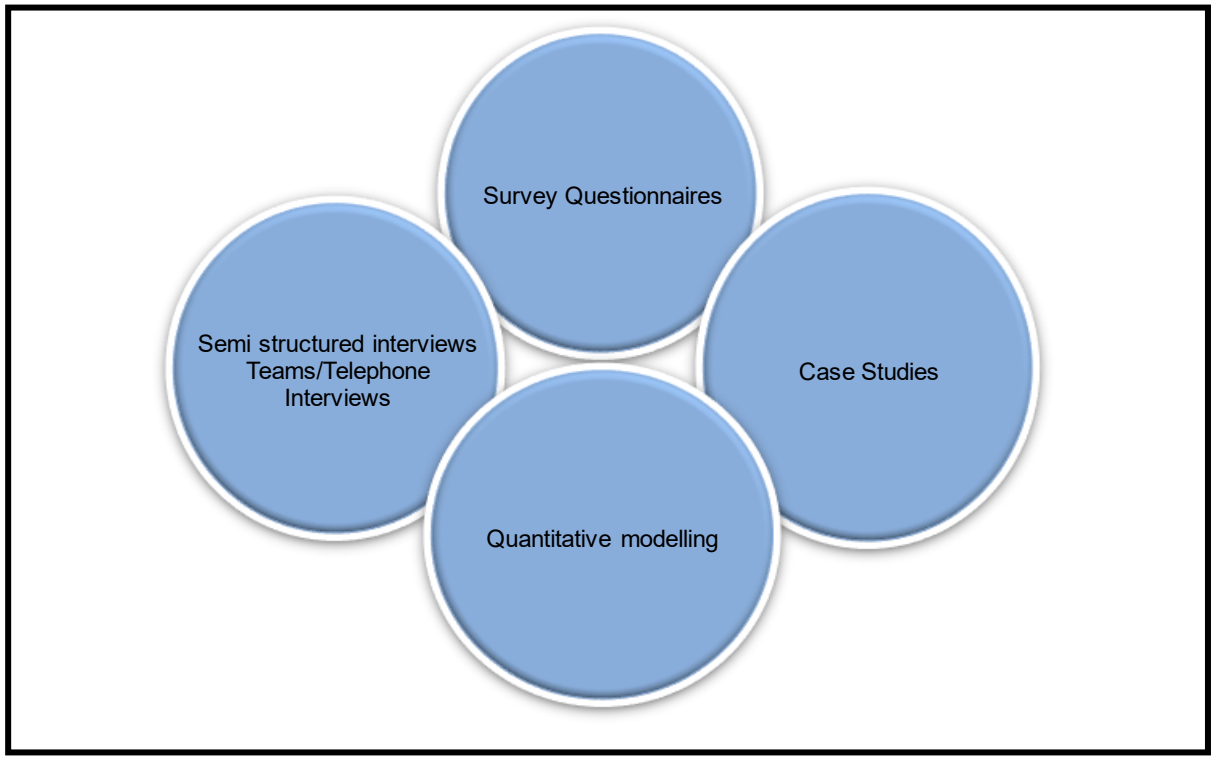


Figure 3.2: Research Instruments

3.5 Data analysis and interpretation

Thematic data analysis was followed, with coding, content analysis and discourse analysis to uncover patterns, themes and meanings in the data collected through semi-

structured interviews, surveys and case studies. The process entailed coding and categorizing themes that emerged from the data, using a combination of inductive and deductive approaches. Coding has been done manually, using Excel, by labelling and organising data into themes and sub-themes. Through content analysis the manifest and latent content of the data, including language, tone, and imagery were examined to understand the underlying meanings and themes.

Triangulation of qualitative and quantitative data was employed to facilitate mixed-methods integration, thereby ensuring a comprehensive understanding of sustainable security of gas supply in South Africa.

Qualitative and quantitative findings were combined with data analysis to explore the economic, social and environmental implications of future supply risks on sustainable security of gas supply in South Africa. By integrating different data sources, the study triangulates the findings, to increase the validity, reliability, and generalizability of the results.

Secondary data analysis followed the steps outlined below.

Familiarize with data: The researcher read and re-read the data to become familiar and gain initial understanding. Data gathered through questionnaires and interviews was classified as primary data, while reports, journal and articles were secondary data. All transcripts and responses were reviewed, synthesised and summarised.

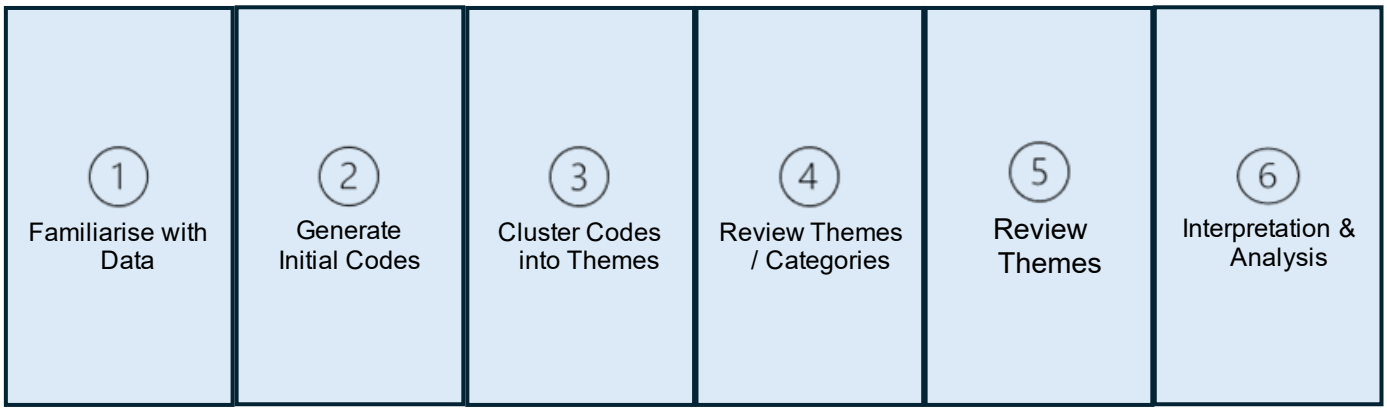


Figure 3.3: Data Analysis Process

Generating initial codes: The researcher identified key features of data, coded the data according to patterns. Codes such as “indigenous gas constraints”, “policy uncertainty”, “infrastructure constraints”, “government interference”, and “lack of policy coordination”, were generated.

Categorization of codes into clusters and themes: Further analysis was undertaken, by funnelling the initial coding.

Themes and concepts: Themes and sub-themes emerged from the questions asked.

Review of the themes: this was done to ensure that themes were coherent but distinct from the other themes. The researcher confirmed that the data supported the themes identified.

Narrative analysis: The themes were interpreted in line with quotes from the literature review in Chapter 5, under analysis of findings.

3.6 Limitations of the study

The gas sector is small and dominated by monopolistic entities and large multinational companies. Based on experience from the data collection process, the sector can be categorised as closed and secretive, and not easy to penetrate for data collection.

- The study is based on publicly available information and interviews with willing participants. No commercially sensitive information was disclosed.
- The research is not about whether gas as is an environmentally friendly source of energy. However, environmental, economic and social factors form part of the analysis.
- The focus of the study is on strategies to enable sustainable security in the supply of gas. This includes opportunities and constraints that hinder the development of the gas market.
- Where sampling is not representative, this has been disclosed.

3.7 Trustworthiness of the study

To ensure the trustworthiness, credibility and reliability of the study, a list of open-ended questions has been devised, which allows respondents to expand and support their arguments, thereby providing more depth to the study.

3.8 External validity (generalisability) or transferability

This was addressed by ensuring the sample was representative across the value chain, or when data saturation was reached, i.e. most of the respondents provided the

same information, with no new data emerging. Responses were cross-referenced and validated. Follow-ups were done where necessary.

3.9 Credibility

The credibility of information in the study could be cross-referenced to publicly available industry information. Checks and balances were attained from various sources in the value chain.

3.10 Reliability

The credibility of information in the study could be cross-referenced to publicly available industry information. Checks and balances maybe attained from various sources in the value chain.

3.11 Objectivity

The objectivity of information in the study could be cross-referenced to publicly available industry information.

3.12 Ethical considerations

The study required careful consideration of ethical principles to ensure the integrity and trustworthiness of the research. Informed consent was obtained from participants, ensuring they understood the purpose, risks, and benefits of the study. Confidentiality and anonymity were maintained, particularly for sensitive or proprietary information. Data protection measures are in place to secure data, in compliance with regulations.

The researcher acknowledged and managed bias, to ensure objectivity in data collection, analysis, and fair representation of diverse stakeholders. Further, transparency and accountability are crucial, with clear documentation of research methods, data sources, and findings, and potential conflicts of interest were observed. By addressing these ethical considerations, the study ensures the trustworthiness and credibility of the findings, contributing to a nuanced understanding of sustainable security of gas supply in South Africa, and informing evidence-based policy decisions.

3.13 Consistency table

Table 5 overleaf is a consistency table, which can be used to track the coherence of the document across all six chapters.

Table 3: Consistency table: Research questions, propositions, data collection and data analysis

RQ #	Research Question or Objective	Prop / hyp #	Proposition / Hypothesis	Data collection detail	Data analysis method
1.	**Research question 1** What are the key factors influencing the current and future gas supply security in South Africa?	**1**	**Proposition 1** **Diversification of gas supply sources.** Increased investment in both domestic and imported gas supply to improve sustainable and security of gas supply in South Africa, thereby reducing dependence on coal for electricity generation.	Google online questionnaires, Microsoft Teams interviews and telephonic interviews.	Synthesized data into codes, subthemes and themes.
2.	**Research question 2** How do technical and infrastructure constraints affect the sustainable security of gas supply in South Africa?	**2**	**Proposition 2** **Infrastructure development and technological advancement:** Expand, maintain and repurpose infrastructure to facilitate gas supply. Gas infrastructure remains the biggest enabler to a sustainable gas market.	Google online questionnaires, Teams interviews and telephonic interviews.	Synthesized data into codes, subthemes and themes.
3.	**Research question 3** What strategies can be deployed to improve the sustainable security of gas supply in South Africa, and	**3**	**Proposition 3** **Policy and regulatory framework –** Laws and regulations that are internally	Google online questionnaires, Teams interviews and telephonic interviews.	Analyse data by breaking down into themes, patterns, trends and similarities

	what are their potential effects on the energy transition?		consistent and aligned with long term national energy transition objectives.		
4.	**Research question 4** How crucial is the collaboration between public and private sector to ensure sustainable security of gas supply?	**4**	**Proposition 4** **Public-private sector cooperation:** Fostering meaningful cooperation between the public and private sectors in the gas supply chain	Google online questionnaires, Microsoft Teams interviews and telephonic interviews.	Analyse data by breaking down into themes, patterns, trends and similarities

CHAPTER 4. PRESENTATION OF FINDINGS AND RESULTS

4.1 Introduction

This chapter presents the qualitative findings and the quantitative results of the study.

Qualitative findings

Qualitative findings are based on the questionnaires and semi-structured interviews held with the respondents. Four open-ended questions were posed, and the findings were analysed and grouped in themes. Participants in the study included industry regulators, government policymakers, academics, researchers, and businesspeople, with a combined experience of over thirty years. Thirty individuals were invited to participate in the study by way of questionnaires and e-mails, and twelve responded positively to the invitation, by completing the questionnaire or interview. The demographics of the respondents is spelled out in the table below.

Table 4.1: Profile of participants

Sector/Department	Number Approached	Number Responding
Academia	2	2
Competition Commission	2	0
Department of Electricity	2	0
DMRE	2	0
Energy regulator	6	6
Energy specialists	3	2
Gas Users Group	1	0
NGOs	3	0
Presidency	1	0
Private sector	8	2
South African Oil and Gas Alliance	1	0
Total	30	12

Quantitative Results

In this section the researcher reviews the trend of the past five years, through the actual gas volumes imported from Mozambique. Based on this data, and the expected gas cliff in 2027/2028, the researcher considers what measures South Africa should take to ensure the gas volumes planned for gas-to-power electricity generation flows into the country, reliably and uninterrupted. The gas volume forecast for the periods leading to 2030 (2026–2029) are based on the IRP 2019.

4.2 Presentation of Qualitative Findings

The findings are presented according to themes and categories that emerged from each research question.

4.2.1 Responses to Research Question 1

Strategies influencing current and future gas supply security in South Africa?

Diversification of sources of gas supply

Exploration and development of indigenous gas should be pursued, although these activities are capital intensive and take a long time to be monetised. Partnership with large multinational companies is recommended, as they bring experience and access to capital.

Importation of LNG would serve as an alternative, in the absence of proven gas reserves that can be exploited. However, LNG infrastructure such as importation facilities such as FSRUs, and storage facilities is underdeveloped.

Access to regional gas supply from Mozambique is under threat due to the gas reserve depletion as reported by Sasol. Alternative solutions from Mozambique, Namibia, and perhaps Angola and Zimbabwe, must be considered.

Shale gas: small-scale operations and large-scale development provide another alternative.

Gas depletion: South Africa faces a looming security of gas supply crisis, given Sasol Gas's communication that it intends to cease gas supplies to third-party traders and external end-user customers by July 2027/28 due to the diminishing reserves in the Pande-Temane gas fields in Mozambique.

Diversification and regional cooperation: diversifying gas supply sources and developing regional (SADC) cooperation can enhance the security of gas supply. South Africa's potential for unconventional gas production, and its participation in regional energy trade initiatives, will be important factors in shaping the future gas security landscape.

Environmental considerations: the effect of gas production and consumption on greenhouse gas emissions will increasingly influence the security of gas supply.

Proposition 1: Increased investment in domestic and imported gas supply to improve sustainability and security of gas supply and reduce dependence on coal for electricity generation.

4.2.2 Responses to Research Question 2

How do technical, economic, and environmental factors interact to affect the sustainable security of gas supply in South Africa?

Lack of infrastructure and LNG technologies: Participants identified indigenous gas; LNG importation infrastructure such as FSRU; storage facilities; and gas pipeline transmission networks across the country.

Investor financial consideration: Views of investors will predominate. Investors will decide whether to invest or not, according to their confidence.

Expanding gas supply and infrastructure requires significant capital investment in exploration, production, and infrastructure. Investors will assess the investment environment, and how conducive to investment it is, taking into consideration risk factors, return on investment, etc.

Advanced technology should be used to minimise the damage to the environment while attempting to stimulate economic growth. We should be able to extract the available resources with minimal damage to the environment.

An integrated approach is critical in the evolving energy landscape. Gas projects must be bankable. Criteria for bankability are multifaceted parameters must be balanced, such as the sustainability agenda, inclusive economic growth, and techno-economic resilience in the energy solutions that are being deployed.

Summary of Proposition 2: Implementation of policies and strategies that will address identified constraints to sustainable security of gas supply in the short to medium term (quick wins), such as technological advancement, infrastructure challenges, and policy and regulatory factors.

4.2.3 Responses Research Questions 3

What strategies should be deployed to improve the sustainable security of gas supply and what effect would they have on the energy transition?

Government policy and legislation: competition from other energy technologies, especially renewables; availability or volume of supply, whether LNG, LPG or biogas; availability of local skills, including expertise; research and development in the sector; and propensity (or lack thereof) to diversify energy sector. Potential for market reforms exits, but depends on regulatory reforms, infrastructure expansion and diversified supply resources, among other factors.

Development of a gas master plan that will give certainty to gas industry investors about the regulatory framework and pricing path.

Ensure policy certainty on regulation to attract investors. Incentivize and provide attractive economic conditions for investors and invest in critical gas infrastructure.

Regulatory dispensation: Adopt regulatory dispensation that is investor friendly, flexible, and predictable. Encourage investment and protect consumers.

Summary of Proposition 3: Laws and regulations that are internally consistent and aligned with long term national energy transition objectives.

4.2.4 Responses to Research Question 4

How crucial is the collaboration between public and private sector to ensure sustainable security of gas supply?

Public-private partnerships play a crucial role in ensuring the sustainable security of gas supply. They bring together the public sector's ability to set policy, manage risk, and align with national goals, and the private sector's expertise, investment, and efficiency. By collaborating on infrastructure, technological innovation, diversification

of supply, and risk management, PPPs can contribute to a more resilient, affordable, and environmentally sustainable gas supply. This collaboration also supports the energy transition, by ensuring that gas remains a stable and cleaner energy source as renewable technologies continue to develop.

Deregulation: No need for government, the private sector can do it alone.

The industry players must be organised to ensure a consistent development and growth of the gas economy. Universities and similar institutions (CSIR, SANEDI, Mintek, etc) must focus on technological advancement but also take into account environmental considerations and all should be buttressed by incentives to invest in the various industries of the gas economy.

Summary of Proposition 4: Fostering meaningful cooperation between the public and private sectors in the gas supply chain

4.3 Summary of Qualitative Findings

The qualitative findings highlight key themes for the development of the gas sector:

- Diversification of source of gas supply – Encourage increased investment in gas production. Support expansion of LNG and shale gas to diversify energy sources and enhance security and sustainable gas supply.
- Infrastructure and technological advancement – Enhance gas infrastructure including, pipelines, LNG facilities, storage and distribution facilities.
- Policy and regulatory environment – Devise and implement policies that attract investment, streamline regulations and create favourable business environment.
- Public and private sector cooperation – Strengthen collaboration between government and private sector to drive investment and innovation in the energy industry.

4.4 Presentation of Quantitative Results

- At present gas contributes between 2% - 3% to South Africa's total energy balance. In the past four years from 2021 to 2024, gas volumes flowing into the country from Mozambique through the ROMPCO pipeline range between 148 million and 163 million gigajoules. This gas was not specifically for gas to power generation, but to

support the entire South African gas market, while table 2 below shows gas volume targets as per IRP(2019).

Key Considerations

- IRP targets: Review the latest IRP updates to understand specific targets for electricity generation capacity from gas. The IRP 2019 outlines the contribution of gas and renewable energies to electricity generation.
- Gas capacity projections determine how dispatchable gas-fired power capacity (in megawatts) is slated to be developed according to the IRP 2019 from the years 2026 to 2029.

4.5 Summary of Quantitative Findings

IRP Targets

The South African electricity system has the following generation options: 38 GW installed capacity from coal, 1.8 GW from nuclear, 2.7 GW from pumped storage, 1.7 GW from hydro, 3.8 GW from diesel and 3.7 GW from renewable energy (IRP, 2029). Next, we consider projected gas-to-electricity volumes.

Gas requirements for gas-to-electricity

- Table 4 below shows gas-to-electricity requirements in MW as outlined in the IRP 2019. The volume of gas needed for each period from 2026 to 2029 is indicated.

Table 4.2: Gas-to-power and gas volume requirements

Years	Gas-to-power (MW/h)	Gas volumes (GJ)
2026	2250	142 020 000
2027	1200	75 744 000
2028	1800	113 616 000
2029	2850	180 036 000
TOTAL	8100	

ANALYSIS

The Current Gas Supply

- South Africa is a gas-constrained country with limited indigenous gas reserves that could be commercialised in the short to medium term. According to Sasol Gas through media statements, there is a steady decline in gas imports and gas depletion (a gas cliff) is imminent in 2027. Sasol has extended its estimate to 2028, but ultimately this decline is unavoidable (naturalgasworld.com).
- In its website, Sasol Gas reports that gas volumes between 160mGJ and 183MGJ annually are imported from Mozambique. These flow into South Africa through the ROMPCO pipeline, supporting industry and contributing about 5% of the GDP.

Supply shortfall

- It is estimated that South Africa's gas needs currently stand at 393 000 000GJ/a, while the current available gas flowing into the country is up to 183 000 000GJ/a, with a shortfall of approximately 210 000 000GJ.
- To meet electricity generation goals of (8100MW) over four years, South Africa would need to double or triple the current gas supply.

CONCLUSION ON QUANTITATIVE ANALYSIS

To meet its current gas supply needs, South Africa should implement the following strategies, which are in line with the findings of this study:

- South Africa must invest in gas and LNG infrastructure to facilitate sustainable security of gas supply into the country.
- Diversify gas supply from natural gas, LNG imports, indigenous gas and shale gas.
- South Africa should pursue a strategic relationship with SADC countries, and African countries further afield, to secure gas supply. The gas of the SADC region should be shared for the development of the region before it is exported to foreign countries such as China, Japan, and the European Union.
- Improve domestic gas exploration and development through public-private partnership with multination oil majors and domestic investors.
- Improve the regulatory and policy environment.

CHAPTER 5. DISCUSSION OF FINDINGS AND RESULTS

5.1 Introduction

This chapter presents a detailed analysis and discussion of the key findings presented in Chapter 4.

Qualitative findings: Responses to most of the questions overlapped. The themes were similar and related. They included: the need to invest in developing the domestic or indigenous gas market; infrastructure development; devising investor-friendly policies and improving regulation; obtaining gas from neighbouring countries; and the importance of public-private sector cooperation. One respondent expressed differing views, such as that investors' financial considerations will predominate and there is no need for government participation. These views point to the need to deregulate the energy sector.

Quantitative findings: The basis for this section is the IRP 2019's description of gas's contribution in the years 2026 to 2030.

5.2 Analysis of qualitative findings

5.2.1 Diversification of gas supply

Gas supplies are characterized as resources, proved reserves, and production. The largest category of supply refers to the quantity of a natural resource that is known to exist with a reasonable degree of certainty, and which can be extracted using existing commercial technology. Reserves are a subset of resources that are known to exist with a reasonable degree of certainty, and which can be economically extracted under current or assumed prices. Resources and reserves are dynamic. Both change when new natural resources are discovered via exploration, as natural resources are extracted, and as prices fluctuate. All estimates of reserves involve some uncertainty, which depends primarily on the amount of reliable geologic and engineering data available at the time of the estimate (Energy Primer, 2020).

LNG is gas cooled to minus 260 degrees Fahrenheit to liquefy it, which reduces its volume to LNG suppliers, enabling them to land cargoes in the highest-priced markets (Energy Primer, 2020). This amplifies the need to establish LNG terminals, as outlined in the Gas Master Plan.

Shale gas is gas found in fine-grained sedimentary rock with low permeability, such as mudstone, claystone and what is commonly known as shale. Gas in shale formations tends to concentrate in natural fractures and the rock adjacent them. Historically, extraction of gas from shale formations has been difficult to achieve (Energy Primer, 2020).

Biresselioglu et al. (2015), Devaraj et al. (2021), and Kim et al. (2024) emphasize the need for diversifying gas sources to improve security of supply. In a global context, diversification of gas sources is vital for improving security of supply, as it reduces reliance on dominant producers and mitigates risks associated with geopolitical tensions, price volatility, and supply disruptions.

South Africa is an energy-intensive economy, relying on coal for its electricity generation. Coal will dominate South Africa's energy sector for a long time if the country does not diversify its energy mix. Gas use in South Africa is limited due to the non-availability of gas in the country.

The release of the Gas Master Plan (GMP, 2024) for public comment is intended to resolve uncertainty in the gas sector. The plan seeks to ensure security of gas supply by diversifying sources, both domestic and international. The GMP emphasizes the development of gas infrastructure, including LNG terminals and storage facilities to support the gas industry. The GMP also emphasizes collaboration with SADC neighbours to ensure energy security. Other initiatives such as exploration and development activities are long-term in nature and will not be monetized in the short term. Some have problems, as evidenced by the recent announcement of TotalEnergies' withdrawal from Brulpadda. Other challenges are from NGOs opposed to exploration and development, who assert that South Africa has enough natural resources (sun and wind) for the transition to renewable energy. South Africa's diversification of gas supply involves securing gas imports, infrastructure development, and policy reforms, among other imperatives.

As noted in *Who Owns Whom* (2024), a bilateral agreement has been concluded between South Africa and Mozambique to facilitate trade in natural gas. A bi-national Gas Pipeline Commission has been established to oversee the transmission of gas from Mozambican gas fields to South Africa. A gas trade agreement between South

Africa and Namibia has also been signed. This is an encouraging development. South Africa ought to participate in bilateral cooperations with its SADC neighbours and countries further afield to establish firm trade relations, emulating developed countries like China and United States. Li (2015) highlights bilateral cooperation China has established, to pursue energy dialogue and cooperation mechanisms with the United States, Japan, the European Union, Russia and many other energy-consuming and energy-producing countries. In international energy cooperation, China not only shoulders broad international obligations, but also plays an active and constructive role.

5.2.2 Infrastructure and Technological Challenges

South Africa is working on expanding its gas infrastructure and technology to support diversification of gas supply (GMP, 2024). There are problems such as financial constraints, policy inconsistencies and lack of coordination. Sustainable gas supply cannot be realised without enabling infrastructure, such as pipelines, gas containers, and storage facilities, from exploration to end use. The whole SADC region has underdeveloped infrastructure, which hampers trade and domestic and regional development of gas.

The Infrastructure Development Act (Act 23 of 2014) aims to provide for the facilitation and coordination of public infrastructure development which is of significant economic or social importance to South Africa. The act is intended to ensure that infrastructure development is given priority in planning, approval and implementation; to ensure that the development goals of the state are promoted through infrastructure development; and to improve the management of such infrastructure during all life-cycle phases, including planning, approval, implementation and operations.

Technology and infrastructure plans are characterized by fast changes and uncertainty regarding the effect of the technological changes on the future energy provision system (IRP, 2019).

There is a school of thought against investing in gas infrastructure, as being not economic, harmful to the environment, and long-term sustainable. Investing in infrastructure is an outdated strategy, if gas is regarded as transition energy, while

renewable energy technology costs are declining. Hence, investing in gas infrastructure may lead to:

- Risk of stranded assets.
- Climate and environmental effect due to methane leakage.

5.2.3 Policy and Regulatory Factors

South Africa's policy and regulatory framework for the gas sector is designed to promote orderly development and facilitate energy security. The following policies and regulatory framework underpin the gas sector: the Gas Act, 48 of 2001, established to promote orderly development of gas in the country; Piped Gas Regulations; the Gas Amendment Bill (2021); and the Draft Gas Master Plan (2024). These legislative and policy initiatives reflect government's commitments to developing a robust gas sector that aligns with national energy goals and socio-economic development objectives.

However, the government is often criticised for not implementing its policies or implementing them poorly. Continuity or consistency in policy implementation is at the centre of slow progress in government programmes, including the energy transition. Another area of concern is the lack of coordination, which results in a regulatory burden, causing businesses to lose time and opportunities. Inconsistencies and lack of proper implementation are always sources of concern for the public.

Wrong structure results in policy failures by making it impossible to provide goals or deliver them due to organisational issues: processes or governance. This could be, for instance, when two institutions such as the Ministry of Climate (running the climate policy) and the Ministry of Energy (managing the energy policy) fight for the superiority of their policies. This could result in non-coherent policy being adopted due to a lack of coordination, and no distribution of benefits to society from the energy sector (Bouzarovski & Simcock, 2017).

In addition, the regulatory environment must continue to be investor friendly to attract domestic and foreign investment, especially in areas where South Africa is lacks skills and expertise.

5.2.4 Public and private sector cooperation

There is a role for both public and private sector in energy reforms, especially with regard to reform of the electricity industry, where Eskom, the monopoly state electricity company, ought to be exposed to competition. It is important to note that good cooperation between the state and the private can lead to many social ills self-solving.

In its position paper, BUSA asks whether there are decarbonisation trajectories that would move the country to net zero by 2050 in ways that would create new industries, income streams and jobs. BUSA is advocating that the country invests heavily in renewable energy, build no new coal-fired power station, and that investment in gas should be for peaking purposes into the 2040s. With regulatory and policy environment supporting this view, business can commit to supporting South Africa's transition to a net zero emission economy by 2050.

Common ground between government and business is inevitable. A transition to cleaner sources of energy is also a reality. No single party can go it alone without the support or cooperation of the other. Keeping the bigger picture in mind will help us to make better decisions and remain focused on outcomes.

5.3 Analysis of quantitative results

Conclusion of qualitative findings

In conclusion, the findings highlight the need for a diversified gas market in South Africa, by securing gas from domestic and international markets. A diversified gas market is fundamental to a diversified energy balance for South Africa, and to achieving the energy transition goals. Infrastructure and technology support a thriving gas sector. In addition, gas energy security can balance economic growth and environmental sustainability. The gas market can achieve long-term sustainability, improved energy access, enhanced economic growth and environmental sustainability if the correct policy is applied.

It is also worth noting that some of the policy documents may be outdated or may have been overtaken by events.

CHAPTER 6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In conclusion, the sustainable security of gas supply in South Africa is influenced by various technical and environmental factors, which apply throughout the value chain. Technical factors include (but are not limited to) infrastructure development, gas extraction and development, LNG import facilities, technology and innovation, and maintenance of existing infrastructure. Environmental factors include climate change commitments, and a just energy transition and a revised energy balance for the country.

Energy security refers to the reliable availability of affordable energy supply to meet the demand of a country, continuously. The IEA (2022) describes energy security as not just about having uninterrupted access to energy, but also about securing energy supplies at affordable prices. It also encompasses a broad range of social, economic and environmental factors.

6.2 Conclusion in relation to Objective 1

Analysis of current and future gas supply

The current gas supply in South Africa is constrained and heavily reliant on imports from Mozambique, transmitted by pipeline. South Africa is an energy intensive economy, relying on coal for its electricity generation. Coal will dominate South Africa's energy sector for a long time if the country does not diversify its energy mix. Gas use in South Africa is limited by the non-availability of gas in the country. Although there are exploration and production activities on the East Coast and West Coast, these might take long to be monetized.

6.3 Conclusion in relation to Objective 2

Constraints affecting the reliable availability of gas supply

The non-availability of indigenous gas and gas infrastructure, stakeholder relations, and policy and regulatory shortcomings are noted time and time again as constraints on the orderly development of gas supply in the country. Addressing these constraints need collaboration across the entire gas value chain. Government or private sector

alone cannot achieve the required results. It should start with improved relations and trust among stakeholders, which will result in mutually beneficial relations. As gas is key to South Africa's decarbonisation strategy, universal access to energy, and economic growth, it is imperative that gas flow into the country, or we will continue to rely on coal for electricity generation.

6.4 Conclusion in relation to Objective 3

Assess South Africa's options to improve domestic and regional gas supply

Gas is expected to be a transition energy on South Africa's road to a decarbonised, greener economy. But if South Africa cannot be powered by renewable energy alone, there are views that gas should play a role as a peaking energy source.

The future gas sector is expected to focus on increasing LNG imports from Mozambique. Lack of LNG infrastructure should not be allowed to stand in the way of achieving this development. There are other private sector initiatives which should be encouraged, aimed at bringing gas through Amatola, Mozambique.

In addition, government must actively pursue cooperation with its SADC neighbours.

6.5 Conclusion in relation to Objective 4

Policy and regulatory environment as an enabler of the gas market

A business- and investor-friendly policy environment must prevail. Investors, both domestic and international, need a stable and predictable policy environment. Much has been said about lack of consistency in policy and regulation. A balance between social, economic and environmental factors should remain central to the energy transition.

Finally, the South Africa gas market across the value chain is facing the following constraints:

- The reliance on imports from Mozambique to supply about 90% of the industrial gas market.
- The current exploration and development activities are nowhere closer to commercialisation.

- Gas developments in neighbouring countries are dominated by foreign multinational companies; there are no guarantees that South Africa will benefit by virtue of being a neighbouring country.
- The ongoing litigation from environmental NGOs opposed to exploration and development of gas activities is retarding the development of gas activities.
- Lack of cooperation between private and public sector, especially in areas of infrastructure development, where capital, skills, innovation and shared risk is much needed to pursue development in the energy sector.
- There is a risk that South Africa could be left with stranded assets if gas pipelines and storage facilities are built, and renewable energy and green hydrogen projects come online.
- At the same time, there is disagreement that South Africa can be powered by renewable energy sources alone. Baseload electricity will always form part of the energy mix of the country.
- In the short to medium term, the South African gas market remains stagnant, facing possible decline in the coming years, furthering imbalance between supply and demand for both energy and industrial sectors.

As Muhongo (2021) argues, the energy sector is key in addressing the challenges faced by the African continent, such as poverty, famine, gender inequality and so on. Most importantly, both fossil fuels and renewables are key in achieving the United Nations' Sustainable Energy for All and the associated Sustainable Development Goal 7, which is access to modern energy for all.

The realty on transitioning will be determined by country's individual circumstances. As Laes et al. (2014) point out, there is no silver bullet solution to decarbonize the energy system, there is no single universal approach for transition to a post-carbon society. As cultures, structures, and practices are context dependent, transition approaches will have to be tailored to the local circumstances.

6.6 Recommendations and further Research

Recommendations

The energy sector is highly dynamic and evolving due to shifting policies, changing environmental concerns, improving technologies, and innovations in renewable

energy. There are also government policies to accommodate transition and attract investment, the question of carbon pricing, and many other factors relating to climate change. As the IRP (2019) notes, assumptions are made and influenced by a fast-changing environment.

Further Research

The energy transition is evolving and there is still much to be done, especially at early stages of the transition. While the study has provided insights, several areas merit further investigation:

- Deregulation of the market and introduction of competition to accommodate emerging businesses.
- Market structures and Infrastructure sharing. Feasibility of access by small players to infrastructure to facilitate competition.'
- Disposal and recycling of Renewable Energy Technology.
- Facilitation of energy imports by emerging businesses.
- Quantitative modelling, which entails analysis into gas demand, supply, diversity and emissions under different scenarios.
- Can South Africa be fully reliant on renewable energy sources and balance socio-economic and environmental factors.

Delimitations

- This study focuses on the main South African national gas supply and does not cover regional geopolitical dynamics and trade flows in depth.
- The interviews were limited to regulators and energy companies and did not include labour and community representatives.
- The study evaluates energy and climate policy and does not cover detailed fiscal or tax policy reforms.
- The study focused on gas as energy transition and does not cover in depth interrelation with other renewable energy sources.

REFERENCES

AEC. (2023). *The State of African Energy Outlook 2023*. Online. Downloaded (05-08-2024) from www.energychamber.org.

AEC. (2024). *The State of African Energy 2024 Outlook Report*. Retrieved from https://energychamber.org- content/uploads/The-State-of-African-Energy-2024-Outlook-Report3.pdf

Aksyutin, O. E., Ishkov, A. G., Romanov, K. V., & Grachev, V. A. (2020). The role of gas in achieving sustainable development goals. *International Journal of Energy Economics and Policy*, 10(4): 463–472.

Auriacombe, C. J. (2017). Towards the construction of unobtrusive research techniques: Critical considerations when conducting a literature analysis, *African Journal of Public Affairs*.

Austvik, O, G. (2016). The Energy Union and security-of-gas supply. *Energy Policy*, Vol *96*, pp 372–382.

Batschauer da Cruz, C. (2018). The OLI Paradigm as a comprehensive model of FDI Determinants: a sub-national approach. *International Journal of Emerging Markets*, *1*(1): 1–33.

Bellos, E. (2018). Sustainable energy development: How can the tension between energy security and energy transition be measured and managed in South Africa? *Journal of Cleaner Production*, *205*, 738–753.

Biresselioglu, M. E., Yelkenci, T., & Oz, I. O. (2015). Investigating the gas supply security: A new perspective. *Energy*, *80*(1):168–176.

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*, 202–212.

Cherp, A., Adenikinju, A., Goldthau, A., Hernandez, F., Hughes, L., Jewell, J., Olshanskaya, M., Jansen, J., Soares, R., & Vakulenko, S. (2012). Energy and security. In *Global Energy Assessment: Toward a Sustainable Future*. Lund University.

Cherp, A., & Jewell, J. (2014) The concept of energy security: Beyond the Four As. *Energy Policy*, *75*, 415–421.

Clark, S., van Niekerk; J., Petrie, J., & McGregor, C. (2022). The role of gas in facilitating the transition to renewable electricity generation in South Africa. *Journal of Energy in Southern Africa*, 33(2), 22–35.

Clark, S., McGregor, C., & van Niekerk, J. L. (2022). Using liquified petroleum gas to reduce the operating cost of the Ankerlig Peaking Power Plant in South Africa. *Journal of Energy in Southern Africa*, 33(2): 15–23.

CSIR. (2023). Improving energy security in South Africa through a more circular energy sector. *Energy and the Circular Economy: Science, Technology and Innovation for a Circular Economy Series*.

Devaraj, D., Syron, E., & Donnellan, P. (2021). Diversification of gas sources to improve security of supply using an integrated multiple criteria decision-making approach. *Cleaner and Responsible Consumption*, *3*(1): 1–12.

DMR. (2019). Integrated Resource Plan (IRP) 2019.

DoE. (2019). The South African Energy Sector Report 2019.

EIA. (2022). South Africa. Report: Retrieved from www.eia.gov/international/analysis/country/ZAF

Energy White Paper. (1998). Retrieved April 2024 from www.energy.gov.za.

Fakhri, J. H., Ceyhun, M., Kaushik, D., Shamala, A., & Orkhan, H. (2020). The role of Azeri gas in meeting European Union energy security needs. *Energy Strategy Reviews*, *28*. https://www.sciencedirect.com/science/article/pii/S2211467X20300183

Farren-Price, B. (2024). Quarterly Gas Market Review: Prices defy European fundamentals, The Oxford Institute for Energy Studies, OEIS online downloaded (04-08-2024)

Gracyzyk, A., Gracyzyk, A.M., & Wegrzyn, A. (2023). Change in gas utilization in the context of sustainable energy management in Poland, *Economics and Environment, 1*(84): 1–25.

Gürsan, C., & de Gooyert, V. (2021). The systemic impact of a transition fuel: Does natural gas help or hinder the energy transition? *Renewable and Sustainable Energy Reviews*, Vol: 138: 110552.

Hasley, R., Bridle, R., & Geddes, A. (2022). *Gas pressure: Exploring the case for gas fired power in South Africa*, International Institute for Sustainable Development. Online downloaded (02-08-2024) at https://www.iisd.org.

Hotelling, H. (1931). The economics of exhaustible resources, *Journal of Political Economy*, *39*(2): 137–175.

Integrated Resource Plan (IRP2010-2030). Retrieved from www.energy.gov.za 18 March 2024 https://www.iea.org/reports/world-energy-outlook-2022/energy-security-in- energy-transitions states

Integrated Resource Plan (IRP 2019). Retrieved March 18, 2024, from www.energy.gov.za/IRP/irp-2019

International Energy Outlook. (2021). retrieved from www.iea.org/countries/south-africa/energy-mix.

Kaberi, M., & Olanrewaju, O. (2022). Sustainable energy transition for renewable and low carbon grid electricity generation and supply. *Frontiers in Energy Research*.

Khan, S., Kumar, A., Luthra, S., Singh, R., & Nwokolo, S. (2023). Africa's path to net zero. *Sustainability, Ethics and Governance*.

Kim, J; Panton, A.J & Schwerhoff, G., (2024). *Energy security and the Green transition*. IMF Working Paper – WP/24/6. Washington DC: International Monetary Fund. Online downloaded at https//: www.imf.org

Li, L. (2015). China's energy security and energy risk management. *Journal of International Affairs*.

Löschel et al., (2010); Matsumoto and Andriosopoulos, (2016); Winzer (2012): Conceptualisation of Energy Security.

Makoni, P.L., (2015). An extensive exploration of theories of foreign direct investment. *Risk Governance & Control: Financial Markets & Institutions;* Vol.5(2): 1–7.

Mkhize, N.E. & Nel-Sanders, D. (2023). The state and progress of the gas to power programme in South Africa. *Africa's Public Service Delivery and Performance Review*, *11*(1). a656. https://doi.org/10.4102/apsdpr.v11i1.656

Molnar, G. (2022). The economics of gas transportation by pipeline and LNG in *The Palgrave Handbook of International Energy Economics*, Palgrave Macmillan.

Mouton, J. (2021): *How to Succeed in Your Master's & Doctoral Studies*.

Muhongo, R. S. (2021). *Energy Transitions and the Future of the African Energy Sector.* Palgrave Macmillan.

NERSA. (2022). Reason for decision on the 2021/2022 determination of inadequate competition in the piped-gas industry report.

Ouki, M., (2023). Prospects for a potential African gas renaissance en route to a 'just energy transition. OIES Paper: NG 185. Oxford Institute of Energy Studies. Online downloaded (05-08-2024) at https://www.oxfordenergy.org/piblications...pdf.

Parker, D. (2024). Role of gas in SA's future energy mix under intense scrutiny. *Engineering News*. https://www.engineeringnews.co.za/article/role-of-gas-in-sas-future-energy-mix-under-intense-scrutiny-2024-04-05-1 (accessed 11 September 2025).

Pesaran, H. M. (2015). *Time series and panel data econometrics*. Oxford University Press.

Pesaran, M. H., & Shin, Y. (1999). An autoregressive distributed lag modelling approach to cointegration analysis. In: S. Strom (ed.), chapter 11. *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium,* Cambridge University Press, pp. 371-413.

Pesaran, M. H., Shin, Y., & Smith R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16 (1): 289-326.

Phillip H. (2007). Global Energy Security: South African Energy Policy and G8 Petersburg Declaration on Global Energy Security. FES Briefing Paper, August 2007.

Pustisek, A., & Karasz, M. (2017). *Gas: A commercial perspective*. Springer.

Rotunno, T. L., & Vézina, P. L. (2016). Heckscher-Ohlin: Evidence from virtual trade in value added. *Review of International Economics*. Advance online publication. https://doi.org/10.1111/roie.12230

Sadowski, M. (1995). Qualitative analysis: What is and how is to begin. *Research in Nursing*.

Schumacher, R., (2012). Adam Smith's theory of absolute advantage and the use of doxography in the history of economics, *Erasmus Journal for Philosophy and Economics*, Vol.5 (2): 54-80.

Sokołowski, M.M., & Heffron, R.J., (2022). Defining and conceptualising energy policy failure: The when, where, why, and how. *Energy Policy*, *161*.

Teljeur, E., Chetty, M., & Hendriksz, M. (2017). Six: Africa's prospects for infrastructure development and regional integration: energy sector. In *Infrastructure in Africa*. Policy Press. Retrieved Jan 29, 2025, from https://doi.org/10.51952/9781447326656.ch006

The South African Energy Sector Report (SAESR) (2022). Retrieved from www.energy.gov.za 24 April 2024.

The South African Energy Balance (2000). Retrieved March 18, 2024, from www.energy.gov.za.

The Presidency of the Republic of South Africa. (2023). Just Energy Transition Implementation Plan 2023-2027. Retrieved www.climatecommission.org.za

Tracking Clean Energy Progress. (2023) Retrieved from www.iea.org/energy- system in February 2024.

Ukwandu, D., (2015). David Ricardo's theory of comparative advantage and its implication for development in Sub-Saharan Africa: A decolonial view. *African Journal of Public Affairs*, *8*(3): 1–18.

USAID. (2018). Power Africa Gas Roadmap to 2030. Power Africa in collaboration with USAID, online downloaded at www.usaid.gov/powerafrica.com.

Volkan, S., & Ediger Berk, I. (2023). Future availability of natural gas: Can it support sustainable energy transition? *Resources Policy*, *85*.

Xia, X., Wu, R., Liu, Y., Wu, J., & Lu, T., (2023). Value of long-term LNG contracts: A theoretical and empirical study. *Frontiers in Earth Science*, Vol.1(1): 1–11.

Yadav, Y., & Shivanand, M. (2014). Behavioural finance: Concepts and conventions. *International Journal for Innovations in Engineering, Science and Management*, *2*(11): 1–11.

APPENDICES

APPENDIX A: PARTICIPATION INFORMATION SHEET

Not used, as interviews were conducted on Microsoft Teams and recorded.

APPENDIX B: PARTICIPATION AGREEMENT FORM

Did not use responded to a questionnaire or were interviewed

APPENDIX C: RESEARCH INSTRUMENTS

Questionnaire attached

APPENDIX D: QUALITATIVE CODING

Attached

APPENDIX E: ETHICS APPROVAL NOTIFICATION

Attached