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The role of natural gas in the current energy transition: A South African Focus

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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

Africa's growing urban populations and industrialisation mean rapid growth in energy demand. Natural gas is facing a potential turning point in Africa. There have been major discoveries in recent years in East Africa, Egypt, West Africa, and South Africa. Natural gas has the potential to mitigate Africa's energy challenges and stimulate economic growth with increased use.

The purpose of this qualitative study was to investigate the role that natural gas plays as an energy accelerator in the current energy transition of South Africa.

South Africa has an energy crisis with increased stages of possible load shedding, and commitments to reduce CO2 emissions. South Africa's electricity mainly depends on coal-based energy through its primary electricity supplier Eskom. For South Africa to adapt to a more diverse energy mix and to enlarge the role of natural gas has not been studied, infrastructure forms a large part of the strategy to grow and transform. However, the natural gas infrastructure of South Africa is underdeveloped and limited but its neighbouring countries, Mozambique and Namibia, have discovered large natural gas reserves that could be accessed to supply South Africa with natural gas.

This qualitative research study used semi-structured online interviews of 17 participants with industry-specific experience and knowledge. A thematic analysis affirmed that natural gas could serve as a bridge between traditional fossil fuels and renewable energy solutions. However, the current underdeveloped natural gas infrastructure imposes limitations. The underdeveloped natural gas infrastructure is mainly due to three causes, limited government support, access to funding and investment, and the supply of natural gas.

KEY WORDS

Energy Mix, Energy Transition, Natural gas distribution, Natural Gas, Natural gas market, Natural gas transmission, Natural Gas Role.

DECLARATION

I, Lize Hough, 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 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: Lize Hough Signature:

Signed at Parktown North

On the 24th day of February 2024.

DEDICATION

To my awesome husband Jacques, and two stunning kids Zak and Elle. Parents Marlise and Gerrit Human, Marina, and Andre Hough.

Thank you for your support and prayers on this journey to change the world and provide energy to all – the futures are bright, wear your sunglasses.

ACKNOWLEDGEMENTS

Thank you to my supervisor Dr Kurai Chitima for your support and encouragement during this research study.

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List of Acronyms

$C0_2$	- Carbon Dioxide
CAGR	- Compound annual growth rate
GDP	- Gross Domestic Product
IPP	- Independent Power Producer
IRP	- Integrated Resource Plan
kPa	- Kilopascal
NERSA	- National Energy Regulator of South Africa
SDG	- Sustainable Development Goals
SEPI	- Sasol Exploration and Production International

CHAPTER 1. INTRODUCTION

1.1 Purpose of the study

The purpose of this qualitative study was to investigate the role natural gas plays as an energy accelerator in the current energy transition of South Africa. As an energy accelerator, natural gas could support and accelerate the energy transition to increase the use of cleaner fuels. Natural gas is defined as ‘a fossil fuel energy source, with the largest component as methane’ (EIA, 2022). The results of the study can provide fresh insight into how best to use natural gas in a national energy mix and can be used by the South African natural gas industry to consider cleaner fuel in the South African energy mix as part of global commitments made to mitigate climate change.

1.2 Context of the study

By 2050, Africa, the continent with the youngest population, is expected to be the home of almost 2,5 billion people (Ferroukhi et al., 2022). Of these 2,5 billion people, the largest percentage will live in sub-Saharan Africa, where there is very little access to clean cooking fuels (International Energy Agency, 2019). In the face of climate change that contributes to the risk of food insecurity related to floods and droughts, Africa is already one of the most vulnerable continents (Pereira et al., 2022).

Globally, the transition to renewable energy can be seen as an immense opportunity to improve the livelihoods of Africa by accelerating economic opportunities. By committing to the Paris Agreement and reducing C0$_2$ emissions, a positive impact can be seen on gross domestic product, job creation, and welfare in Africa (IRENA & AfDB, 2022). The Paris Agreement is a legally binding international treaty that was implemented in November 2016 (Unfccc, n.d.; IRENA & AfDB, 2022), and was signed by all African countries that committed to mitigating climate change and contributing to the effort to reduce C0$_2$ emissions. Each country is responsible for submitting a climate action plan, known as the

National Determined Contribution. Africa has made some progress on some metrics; however, it is still considered an energy-poor continent and 45% of its people lack access to electricity (International Energy Agency, 2019).

Together with the commitments made in the Paris Agreement, Africa committed to the Sustainable Development Goals developed by the United Nations. Sustainable Development Goal 7 states: *'ensure access to affordable, reliable, sustainable and modern energy for all'.* However, 600 million people in Africa do not have access to clean and reliable electricity (International Energy Agency, 2019).

Although fossil fuels still dominate the existing domestic energy supply in Africa, renewable resources in Africa present numerous opportunities to transition to less dependence on fossil fuels. Solar, wind, hydropower, and bioenergy account for most of these renewable resources. Africa is a resource-rich continent with great potential for low-cost clean energy solutions (International Energy Agency, 2019).

Natural gas is facing a potential turning point from being a small player in the energy mix to being a more prominent part of it. This is especially true in Africa, where recent discoveries have been made (International Energy Agency, 2019). This could play a vital role in the energy transition not only for Africa, but particularly for southern Africa. Natural gas is one of the fastest growing sources of energy in Africa, showing a compound annual growth rate (CAGR) of 4,2% per year from 2011 to 2019 (IRENA & AfDB, 2022). In 2021 the natural gas reserves in Africa totalled more than 620 trillion cubic feet. The largest amount of these reserves is held by Nigeria. Algeria has the second largest natural gas reserves, followed by Mozambique (Kamer, 2023). The share of gas in the energy mix for sub-Saharan Africa is only 5%, which is globally, among the lowest (International Energy Agency, 2019).

The energy mix of southern Africa is very different from the rest of the African continent, mainly due to the situation in South Africa. Unlike other African countries, South Africa still relies mainly on coal as its main energy source (International Energy Agency, 2019). South Africa's coal-dominated energy

economy is driven by abundant coal reserves and an electricity sector based on coal-fired power stations. The well-established electricity network makes South Africa one of the countries in sub-Saharan Africa with the highest rate of access to electricity (International Energy Agency, 2019).

Despite abundant coal reserves, South Africa faces major challenges with energy shortages that caused the implementation of loadshedding. Loadshedding can be defined as a measure that is used to provisionally cut the supply of electricity to reduce the load placed on the electricity grid (Mbomvu et al., 2021). Since 2008, South Africa has experienced major power shortages due to maintenance problems at power stations operated nationally by Eskom, its only public power utility (Clark et al., 2022). Many power plants operated beyond their maintenance window, putting even more strain on power plants that are in mid-life. Maintenance of power stations is not the only cause of loadshedding; an array of reasons could be listed, including, but not limited to, corruption, lack of skills, and internal mismanagement (Mbomvu et al., 2021).

The infrastructure for natural gas in South Africa is still relatively underdeveloped, and natural gas constitutes only 3% of the current energy mix (Clark et al., 2022). The underdeveloped infrastructure and low percentage demand are mainly due to the abundance of low-cost coal in the country, including 92% of electricity generated from coal-fired power stations (Asamoah, 2006). Another reason for the underdeveloped infrastructure is the limited supply of natural gas in South Africa.

Natural gas has the potential to mitigate South Africa’s energy challenges and stimulate economic growth with increased use. Both neighbouring countries, Mozambique and Namibia, have large natural gas reserves that can be used to supply South Africa with natural gas.

The proven natural gas reserves in Mozambique amount to 2,6 trillion cubic feet. Sasol Mozambique, together with other stakeholders, is currently building additional natural gas wells to extract gas and increase the supply of gas to South Africa through the Maputo pipeline. Sasol Petroleum Mozambique Limitada (SPM) holds a Production Sharing Agreement (PSA) licence in the Inhambane

province of Mozambique. In addition, a Petroleum Production Agreement (PPA) is held by Sasol Petroleum Temane (SPT) and its partners. The PSA development project covers the integrated development of oil and gas reservoirs contained in the Inhassor, Temane and Pande fields. The PSA development project by Sasol is structured into two scopes, namely the PSA OBL scope and the PSA IBL scope. The scope of OBL will include additional natural gas wells and flowlines, and the scope of PSA IBL will include natural gas processing facilities and LPG processing facilities. The PSA development project will supply natural gas and maximise the value of gas for the Mozambican and South African markets.

The South African government has policies in place to support the growth of natural gas as a source of energy. In addition to the policies already in place, a major advantage of piped natural gas in residential areas of South Africa is its affordability. The price of natural gas is also more stable and is not prone to price fluctuations, as in the case of crude oil products. It also has a smaller carbon footprint. Currently, gas is a major consideration for developers to increase the identified value of properties in South Africa.

This aligns with the targets set in the Paris Agreements and the Sustainable Development Goals. These goals are to mitigate climate change and global warming by substantially reducing C0$_2$ emissions to reach Net Zero by 2050 (United Nations Framework Convention on Climate Change, 2015). These are strongly supported by the 17 Sustainable Development Goals, one of which is *SDG 7: Ensuring access to clean energy for everyone*. It is firmly agreed on in the White Paper on the Energy Policy of the Republic of South Africa, 1998.

> *The development of the gas industry will stimulate inter-fuel competition, provide environmental benefits through lower emission in contracts to coal and oil, provide greater options for industrial thermal application, and increase the diversity of fuel supplies and hence improve South Africa's energy security (Department of Minerals and Energy, 1998).*

1.3 Research Problem

The development of gas infrastructure in South Africa is a major challenge; the gas network in both southern Africa and Africa is very limited and underdeveloped (United Nations Economic Commission for Africa, 2020) and in South Africa, natural gas is transported via transmission, distribution, and reticulation pipelines. Its main pipeline is the 1080km transmission pipeline owned and operated by Sasol (Clark et al., 2022).

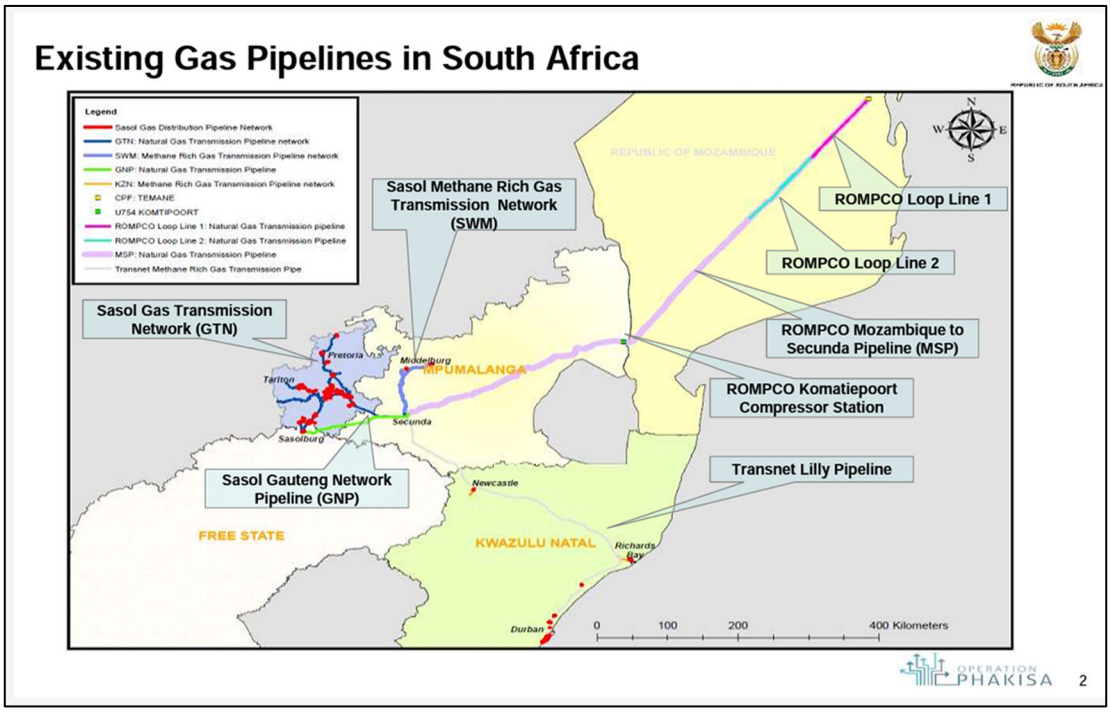


Figure 1.1: Existing Gas Pipeline in South Africa

South Africa will have to rapidly adapt to a more diverse energy mix due to global pressure to mitigate climate change and reduce C02 emissions. Natural gas can play this role to support the South African economy and to decarbonise (Chaumontet et al., 2022). The energy transition in South Africa must be just and fair to all, supporting equality, fighting poverty, and creating jobs.

For this research study, the objective included identifying the causes of an underdeveloped gas infrastructure in South Africa. Qualitative research was carried out to support the research problem and report on the causes. To date, very few academic studies have published data on the natural gas industry in South Africa. Limited research is available on the expansion of natural gas in the

energy mix of Africa, with little or limited studies encouraging further studies in this subject area. Furthermore, the gas industry itself is limited and underdeveloped in Africa and South Africa. In fact, the continent lacks practical applications and, in parts, the actual existence of such. Included in the research problem is the assumption and business case that natural gas could accelerate the energy transition.

South Africa has the means and policies to promote a better developed gas infrastructure, which is supported by the South African Gas Master Plan. However, in addition to supporting policies, other strategies must also be in place to ensure the successful implementation of a better developed gas infrastructure and an increased supply of gas in South Africa. Therefore, questions arise as to the reasons for the lack of action to increase the energy contribution of natural gas. The option has not been a priority among the solutions to the country's energy sources. As a result of the limited effort to increase the percentage of natural gas in the energy mix, the market for natural gas remains constrained. The lack of effort to increase the percentage of natural gas could be due to a few considerations, namely infrastructure costs, regulations and licences, political instabilities, and credit ratings. All these play a major role in large infrastructure decisions and investments. Currently, the natural gas infrastructure supports only the transmission of gas to three provinces in South Africa. In the remaining six provinces, both industry and customers are excluded from access to piped natural gas.

Globally, natural gas plays an important role in the energy mix; however, the role that natural gas can play in South Africa has not been as well understood as in other countries (Mokrani, 2022). Only a limited number of studies have been published on the role that natural gas can play in the region, leaving a gap in a country endowed with coal resources (Mokrani, 2022). A better understanding of the role of natural gas in the provision of energy within a coal-dominated mix can facilitate the transition away from fossil fuels, to become more in line with the Paris Agreement.

Internationally, the pressure to commit to mitigating climate change and transitioning to a less carbon-intensive energy system is on the rise. As a

signatory to the Paris Agreement, South Africa will have to transition and show support. If carbon emissions remain unchanged, the country faces the risk of losing opportunities to export and trade internationally, resulting in massive financial and economic threats, among others.

1.4 Research questions

This study is based on how the role of natural gas can accelerate the South African energy transition from mainly coal-fired power generation to power generation from more sustainable energy sources. If the gas infrastructure were better developed and more accessible, how would it support the transition of energy in South Africa?

This study aimed to address the following research questions:

1. What are the main causes of the limited and underdeveloped gas infrastructure in South Africa, and could the supply of natural gas be one of the main causes?
2. How can natural gas be a strong option to consider in a national energy mix that supports lower C0$_2$ emissions in an economy dominated by coal?
3. What factors are impeding the implementation of the national gas policy in SA?

1.5 Significance of the study

This study will contribute to the body of knowledge on how the South African natural gas infrastructure can expand to provide cleaner electricity to customers. To date, very little research and data have been published on the role of natural gas in South Africa. The significance of this study is to contribute to the already limited knowledge base that supports the importance of natural gas in the energy mix. The study will identify gaps in the existing knowledge base to open opportunities for further academic research.

The significance of this qualitative study is to gather data that can build confidence in the role that natural gas could play in the energy transition of South

Africa. The significance of the findings of this study could support business cases and open opportunities to convert diesel power generation to natural gas power generation. Natural gas is a cleaner fossil fuel for half the price.

At this stage, smaller privately owned companies like Novo, Gigawatt, and Renergen are expanding their private sales volumes. Data centres like Teraco also use natural gas. Gas is used by Sasol for their internal processes in both Secunda and Sasolburg. However, the private sector uses gas mainly for heating and electricity generation.

With the signing of the Paris Agreement in 2015, South Africa is committed to mitigating climate change by taking action to reduce $C0_2$ emissions. South Africa's energy systems are still heavily dependent on coal, followed by crude oil and renewables (Clark et al., 2022). The country faces the risk that pressure from international markets will demand compliance with the Paris Agreement among many policies and frameworks to unite forces to mitigate climate change; it is fully committed to the Copenhagen Accord to reduce its emissions by 42% in 2025 (Audat, 2021).

The aim of this study was to investigate how the role of natural gas can accelerate the energy transition in South Africa and to determine how facilitators of natural gas distribution, such as the infrastructure for natural gas in South Africa, can grow to supply more provinces with piped gas. The findings will contribute to global efforts to mitigate climate change by reducing $C0_2$ emissions and transitioning to low carbon power generation plants. The study also aims to identify economic benefits and business opportunities. With the South African expansion of the gas network, numerous opportunities will follow, including job creation and the security of the electricity supply.

Another outcome of this qualitative study includes findings on the process and the way forward to develop a larger infrastructure to transmit and distribute natural gas in South Africa. The development of the gas market presents an opportunity to strengthen international investment and attract various new industries. Developing and investigating alternative sources of reliable and

affordable energy could open opportunities for South African energy companies to design and build alternative sources.

The availability of reliable energy sources could provide the opportunity to expand the energy mix of South Africa and increase the share of renewable energy. Stakeholders should place greater emphasis on structural changes to support renewable energy (Audat, 2021). South Africa can reposition itself and build a stronger economy by ensuring access to reliable energy. This access could contribute to employment, a higher standard of living, and an inclusive economy.

1.6 Delimitations of the study

This study investigated the role that natural gas can play in the energy transition of South Africa. As a qualitative study, the researcher collected in-depth data from a small sample in a time frame of one month.

The types of participants were selected from a publicly published list of participants working in the oil and gas industry of South Africa. The participants were dealing with a concrete reality rather than a wide-spread discourse or theories.

The political dynamics and position of South Africa and Mozambique were not part of the research study.

1.7 Definition of terms

This study includes the key words defined below.

Energy transition – ‘is the transition from hydrocarbon dependence across the economy toward greater reliance on cleaner energy sources’ (Porter & Hardin, 2020). The energy transition is a global effort to gradually transition from a fossil-based energy system to a zero-carbon energy system by 2025. It is an international effort to decarbonise the energy sector globally, mitigating the devastating effects of climate change and global warming (IEA, 2019).

Energy mix - Global production is mainly the burning of fossil fuels (Ritchie & Roser, 2022). The energy mix of the countries differs according to the proportion of types of energy used. These are a combination of primary energy sources, including fossil fuels, nuclear energy, and renewable energy. The energy mix of a country is made up of available energy sources balanced by the energy supply and demand of it.

Natural gas distribution – is the last step in delivering natural gas to the end user. Natural gas is distributed through pipelines, where end users directly receive gas. Local distribution companies distribute natural gas through pipelines or deliver natural gas in cylinders (Audat, 2021).

Natural gas - worldwide, natural gas is strongly supported as a part of a larger percentage of the energy mix and can be defined as; 'a fossil fuel energy source with the largest component as methane' (EIA, n.d.). Natural gas is (Natural Gas Definition (2011),

> *a combustible mixture of gaseous hydrocarbons that accumulates in porous sedimentary rocks, especially those yielding petroleum, consisting usually of over 80% methane together with minor amounts of ethane, propane, butane, nitrogen, and, sometimes, helium.*

Natural gas transmission pipelines are used to distribute natural gas to end users through distribution, as seen in the figure below.

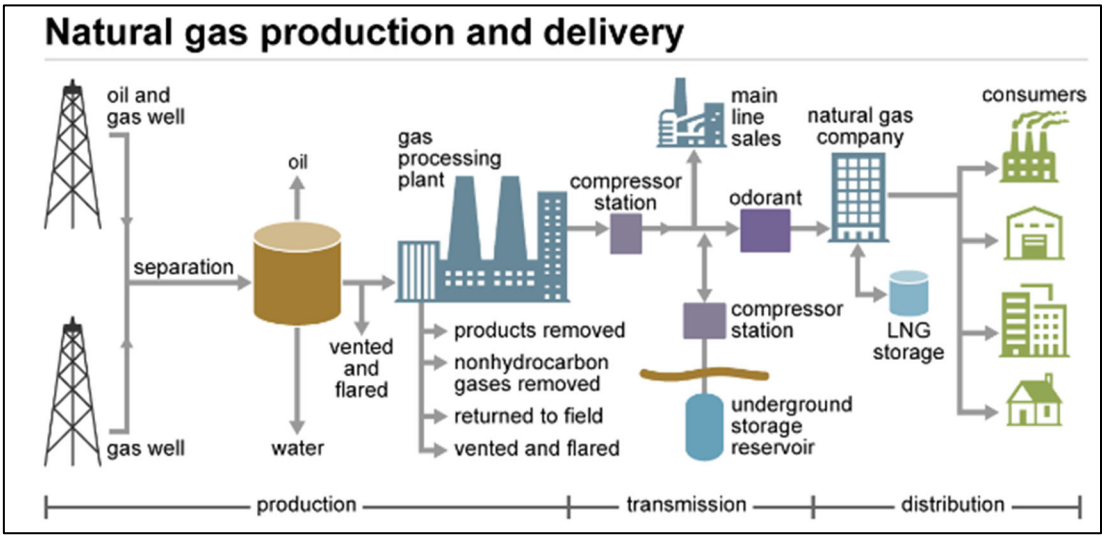


Figure 1.2: Natural Gas Production and Delivery

(EIA, 2023)

The **role of natural gas** in the energy mix of a country is the level of contribution to the production and demand to the energy sector of a country and is determined by the percentage of use (Chaumontet et al., 2022).

1.8 Assumptions

In undertaking this research, a certain assumption is made; that the growth of natural gas usage in the energy mix of South Africa depends on the effective transmission of natural gas to South Africa.

Qualitative assumptions guided this study (Creswell, 2018). The ontological stance assumes that multiple realities and perspectives are received from participants during the interview sessions. This would assume that the researcher reports different perspectives, as themes develop during the findings in the context-bound study. Reporting these perspectives should include quotes as evidence from participants.

The research carried out was based on inductive forms of knowledge (epistemology). The researcher is closer to some of the participants and has a professional working relationship with them. The researcher described in detail the context of the study, methods, and revision where necessary (methodological), while also acknowledging potential subjectivities, and openly discussed these in conjunction with those of the participants (axiology).

The researcher explicitly recognises and acknowledges the value-laden nature of the study.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

This chapter investigates the role that natural gas plays as an energy accelerator in the current energy transition of South Africa, including the results of the focused research questions listed in Chapter 1. The results of the study can provide fresh insight into how best to use natural gas in a national energy mix and how the South African natural gas industry can use it to consider cleaner fuel in the South African energy mix as part of the global force to mitigate climate change.

South Africa is a developing country with an energy supply that has been dominated by coal for at least the last 30 years, although other primary energy sources have been introduced. In 2016, coal represented 69% of the primary energy supply, followed by crude oil at 14% and renewables at 11%. Nuclear contributed 3%, while natural gas contributed 3% to the total primary supply in the same period. South Africa accounts for total emissions of 464 million tons of $C0_2$ per year from fossil fuel combustion and industrial processes. Sasol, a global chemical and energy company, accounts for 67 million tons of $C0_2$ per year, and Eskom accounts for 201 million tons of $C0_2$ per year (Keneilwe Ratshomo & Ramaano Nembahe, 2019).

2.2 Background Discussion Frame

The South African power system has undergone several changes and has been reformed in various ways throughout the pre-apartheid and post-apartheid years. South Africa has a growing population with a growth rate of 1,43%, resulting in an increased energy demand that puts even more pressure on the national energy system. The South African power system is still dominated by coal; however, it will have to transform due to the global drive to mitigate climate change (Orthofer et al., 2019).

Across the world, many steps are being taken to mitigate climate change. One such step is investing in renewable energy. Since energy sources such as solar

and wind do not produce greenhouse gases, it is believed that countries can reduce their emissions and fight climate change by investing in these renewable energy sources (Anderson, 2003). Another step in reducing climate change is to reduce deforestation. Deforestation has been associated with increased temperatures, increased carbon dioxide emissions and affected water cycles that lead to droughts and other extreme weather events (Nerger, 2018).Climate change can also be fought by improving energy efficiency. Improved energy efficiency contributes to reducing C02 emissions and addressing the growing energy demand (Dhar et al., 2018). Investing in renewable energy, reducing deforestation, and improving energy efficiency are just some of the steps that countries take to reduce their emissions and fight climate change.

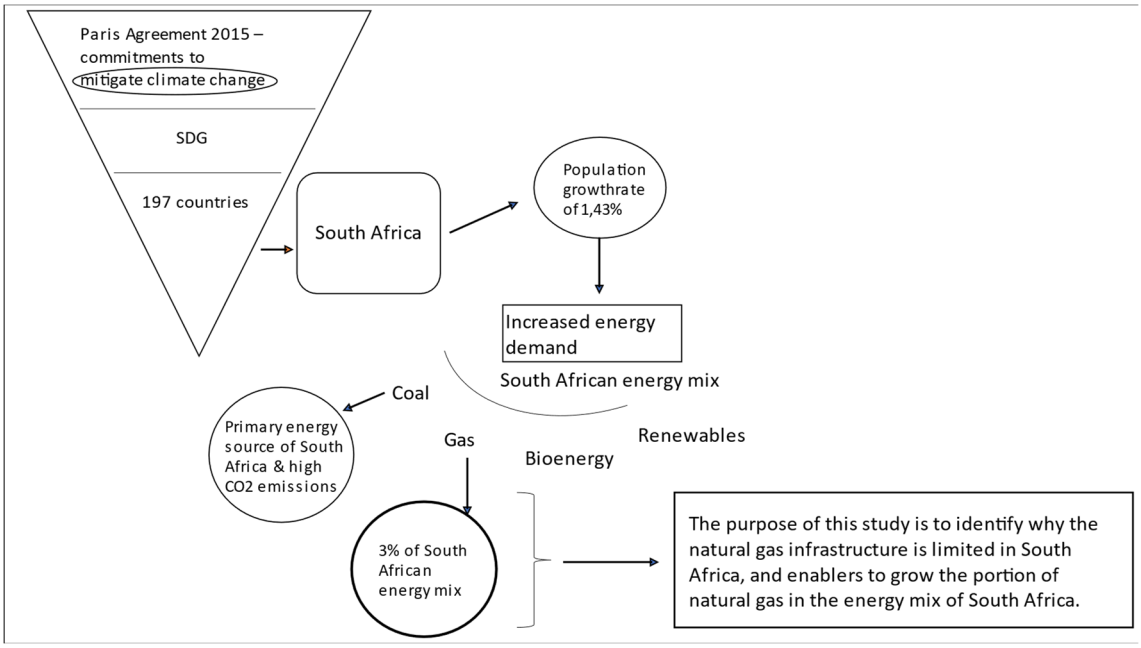


Figure 2.1: Conceptual Framework

As the main energy provider in South Africa, Eskom faces numerous challenges in meeting the high energy demand. Since 2007, the country has been faced with an ongoing energy crisis that poses massive economic threats. Some of these challenges in the energy system are due to outdated power generation and the lack of maintenance of coal-fired generators, resulting in an immense capacity shortage. The massive financial debt profile of Eskom is a huge risk to the financial stability of the country. However, a large percentage of customers have not yet been connected to the national grid (Orthofer et al., 2019).

The South African economy is still highly dependent on consumers who use carbon-intensive energy solutions, resulting in C02 emissions that are approximately twice the global average (Orthofer et al., 2019). To date, natural gas has played a minor role in the energy mix. However, as supported in the South African Gas Master Plan, natural gas could play a larger role in the energy transition of South Africa (Audat, 2021).

As one of the signatories to the Paris Agreement and committed to mitigate climate change, South Africa will have to rapidly adapt to a more diverse energy mix. Natural gas can play this role in supporting the economy and decarbonising the energy system to meet its global commitments (Chaumontet et al., 2022). This energy transition must also be just and fair for all, supporting equality, combating poverty, and creating employment.

By moving to a more diverse energy mix, South Africa could be able to address both climate change concerns and provide better energy security. Previous research has suggested that increasing the energy mix of a country can improve energy security (Akrofi, 2021).Based on data collected between 2000 and 2017, the African countries with the most diverse energy mix are Kenya and Morocco (Akrofi, 2021).

Energy diversity refers to the combination of variety and balance toward a total energy mix. A country with high energy diversity has a variety of sources, with a balanced proportion of each in the energy mix. Both Morocco and South Africa have seven different sources of energy in their energy mix – the highest in Africa. However, although South Africa has many sources of energy, the mix of energy is much more concentrated and most of the energy is produced from coal (Akrofi, 2021). Increasing energy diversity can improve energy security, access to energy, and environmental sustainability.

The Member States of the United Nations adopted the 2030 Agenda for Sustainable Development in 2015 (United Nations, 2015), which includes 17 Sustainable Development Goals (SDGs). These goals require the action of all countries to end poverty, improve health, provide access to energy and water, and preserve our natural heritage. Sustainable Development Goal 7 specifically

aims to ensure access to affordable, reliable, sustainable and modern energy for all. Every unit of energy saved, through manufacturing or social means, is a unit that does not need to be generated.

The SDGs established by the United Nations (UN) play a significant role in driving a global energy transition. SDG 7 recognises that energy plays an important role in reducing poverty, driving economic growth, and contributing to reducing climate change. Having access to reliable and affordable energy has long been recognised as contributing to the reduction of poverty (Asghar et al., 2022).People without reliable and affordable energy are forced to turn to less efficient and more expensive alternatives such as wood, charcoal, and kerosene. These expensive alternatives can also cause health problems, lead to poor educational performance, and impact household income (Kanagawa & Nakata, 2008).

Access to reliable and affordable energy contributes to economic growth, social development, and improved quality of life (Bilgen, 2014).Recognising the importance of energy and taking steps to provide affordable clean energy contribute to eradicating poverty, promoting economic growth, and addressing climate change.

2.3 Research Question 1: Natural Gas Infrastructure in South Africa

Compared to other countries, South Africa has an underdeveloped gas infrastructure. This is mainly due to coal being the main energy source; South Africa has an oversupply of coal. The main transmission lines in South Africa are the Sasol Gas pipeline, the ROMPCO pipeline, and the Lilly pipeline. These pipelines distribute gas to only three provinces in South Africa.

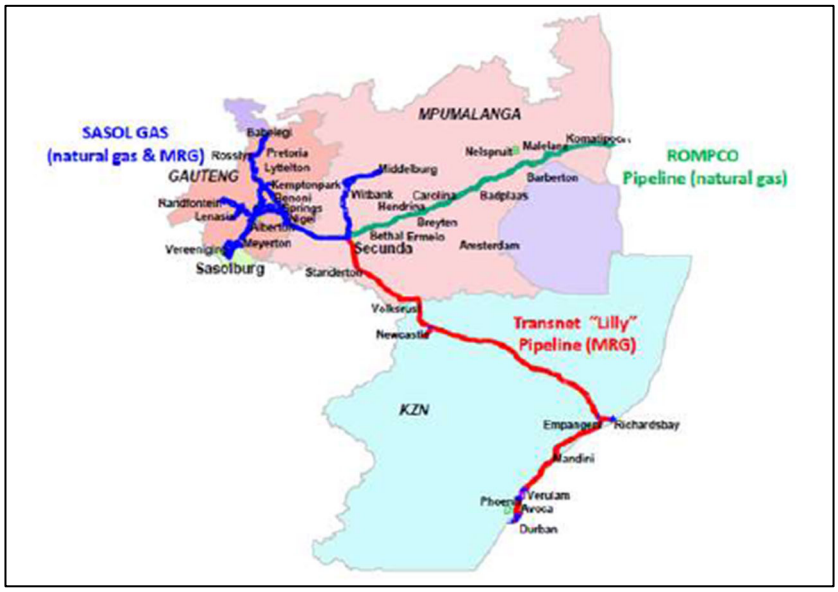


Figure 2.2: Main Natural Gas Transmission and Distribution Pipelines

(Audat, 2021)

The gas demand from these three provinces is divided into Mpumalanga with a gas demand of 110PJ, Gauteng with a demand of 50PJ, and KwaZulu-Natal with a demand of 20PJ (Chaumontet et al., 2022).

Most of South Africa's natural gas is imported from Mozambique (Ross 2020, n.d.).This neighbouring country has many oil fields and is a major producer and exporter of natural gas in Africa and the rest of the world. The country discovered enormous gas reserves in the Rovuma Basin in 2010; one of the world's largest gas discoveries in recent years (Gafur Nazordine Mahomed Bay, 2017).The Rovuma Basin is located off the coast of northern Mozambique and is estimated to contain more than 190 trillion cubic feet of natural gas (Bay & Hong, 2017).

Due to the large natural gas reserves, additional wells are constructed to extract more natural gas and increase the supply of natural gas to South Africa by 2026. In addition to the new wells constructed by Sasol, to extract more natural gas and increase the supply of gas, other large construction companies such as Gigajoule and MGC (Matola Gas Company) are working on similar construction projects.

The development of the natural gas industry in Mozambique is expected to bring significant economic benefits to the country, including increased employment opportunities, increased government revenues and improved infrastructure

(Gafur Nazordine Mahomed Bay, 2017).However, developments surrounding natural gas projects could negatively impact local communities through displacement and dispossession (Namaganda et al., 2022). Islamic attacks have also been problematic since 2017, with local communities being attacked and PNG projects suffering major damages (Daly, n.d.).The current government is proving unsuccessful in managing lawlessness and humanitarian issues, and it is often up to private organisations to ensure the safety of local communities, the proper management of resources, and the protection of the environment (Namaganda et al., 2022).

The natural gas produced in Mozambique is shipped mainly to overseas markets (Namaganda et al., 2022). Most of South Africa's natural gas imports come from Mozambique through a transmission pipeline (Ross, 2020). The ROMPCO pipeline extends from Pande and Temane in Mozambique to Secunda in South Africa (Putter, 2018)and has been in operation since 2004 (Putter, 2018); it is responsible for supplying Sasol's petrochemical plant with natural gas (Salimo et al., 2020).

The 355km long Sasol Gas pipeline starts in Secunda and connects Johannesburg, Pretoria, and Sasolburg. The distribution pipeline has an input pressure of 4,500 kPa and, when it enters various distribution areas, the pressure is reduced to 625 kPa (Audat, 2021). Sasol Synfuels produces and supplies methane-rich gas to the Mpumalanga distribution network. The input pressure of this distribution pipeline is 300 kPa. The Transnet-owned Lily pipeline is fed by the same methane-rich gas that supplies the Mpumalanga distribution network (Audat, 2021).

2.3.1 *Proposition 1*

The major causes for the limited and underdeveloped South African gas infrastructure could be due to an abundance of coal supply and a limited, to non-existent need for a more developed gas infrastructure.

As defined in the previous sections, the natural gas infrastructure is limited and underdeveloped, presenting challenges to the growth and supporting role of

natural gas in the energy mix of South Africa. The causes of underdeveloped infrastructure had to be identified and defined to expand the role of natural gas.

2.4 Research Question 2: Natural Gas as a part of the energy mix

Natural gas plays an important role in the global energy mix. It represented almost 24% of the global primary energy consumed in 2018 (Audat, 2021). In the global energy mix, natural gas has grown in importance, particularly as nations strive to transition to cleaner energy sources to combat climate change (Renewable Energy Agency, 2022). Natural gas, after oil and coal, is the third largest energy source in the world and is widely used to produce power, home heating, and industrial activities (Renewable Energy Agency, 2022).

To mitigate the devastating effect that climate change and global warming could have on both humanity and the environment, the world needs to rapidly decarbonise. To achieve this global reduction in $C0_2$ emissions, fossil fuels must be phased out. In the transition to net zero, natural gas can play a vital role in the transition from intense fossil fuels to renewable energy (Chaumontet et al., 2022). One of the key advantages of natural gas is its relatively low carbon intensity compared to coal and oil. When burning natural gas for energy, less $C0_2$ and almost all other air pollutants are released into the atmosphere compared to when burning coal or petroleum products for the same amount of energy (Natural Gas and the Environment – US Energy Information Administration (EIA), 2023). Natural gas emits around 40% less $C0_2$ than coal when burnt and approximately 20% less than oil (Gould & McGlade, 2017). As the world transitions to a low-carbon economy, natural gas is an attractive option for reducing greenhouse gas emissions in the short to medium term.

In addition to its lower carbon emissions, natural gas is also a flexible source of energy that can be used to complement renewable energy sources such as wind and solar (Mirzaei et al., 2019). Gas-fired power plants can rapidly increase or decrease production. Due to natural fluctuations in the production of renewable

energy, this agility in supply can help ensure a stable and reliable supply of electricity (Glensk & Madlener, 2019; Mirzaei et al., 2019).

However, natural gas is not without environmental drawbacks. Methane, the main component of natural gas, is a powerful greenhouse gas that has a much greater warming potential than C02 over a 20-year period (CITE). Methane leaks during the production, transportation and distribution of natural gas can offset some of the climate benefits of using natural gas. Efforts are currently underway to reduce these emissions (Schneising et al., 2020).

Despite these challenges, the role of natural gas in the global energy transition is likely to remain significant in the coming years. Natural gas can provide a bridge to a cleaner energy future by replacing more carbon-intensive fuels such as coal and oil while complementing renewable energy sources (Karasalihovic, Maurovic, & Sunjerga, 2003). As the world moves toward decarbonisation, natural gas is likely to continue to play a key role in the energy mix. However, efforts will need to be made to reduce its environmental impact.

Currently, natural gas makes up only 3% of the South African energy mix. This percentage is even lower when only household energy usage is considered. According to data from a survey conducted by Ye, Koch and Zhang (2018), 71.5% of households in South Africa consume electricity, while only 1.1% use gas supplied through a public network or purchased in cylinders. Water heating inefficiencies are problematic, with some households contributing 40-50% of their monthly electricity consumption to heating water (Ye et al., 2018). During the winter months, South African households continue to use mainly electrical heating due to limited residential gas heating infrastructure (Berkouwer, 2020). To decarbonise South Africa's coal-dominated economy, the role of gas will have to expand and play a greater role as a transition fuel. Currently, the South African petrochemical and chemicals sector annually consumes approximately 180 PJ of gas (Chaumontet et al., 2022).

South Africa imports its natural gas from Mozambique using the Sasol Gas pipeline. These gas fields are in Temane and Pande in Mozambique, which supplies around 120 million gigajoules to South Africa using the Sasol Gas

pipeline (Ratshomo & Nembahe, 2019). Natural gas was only 3% of the South African Energy mix in 2016, while domestic production was 18%. In the same period, imports amounted to 82% (Ratshomo & Nembahe, 2019).

The natural gas value chain in South Africa is divided into three components, namely upstream, midstream, and downstream. The exploration and production of natural gas are included in the upstream section. The demand for natural gas in the upstream section is predominantly imported from Mozambique by PetroSA, Sasol Exploration and Production International (SEPI) and Tetra4 (Audat, 2021).

The role of the mid-stream sector is to transport and store natural gas in South Africa. Here, there are only three companies that can transport natural gas, namely Sasol Gas, ROMPCO, and Transnet (Audat, 2021). The transmission line, the ROMPCO pipeline, transports gas from Mozambique to Secunda in Gauteng and to Durban using the Lilly pipeline that is owned by Transnet (Audat, 2021). The downstream sector is responsible for the distribution of natural gas to the end user. Currently, Sasol Gas is still dominating the distribution sector, followed by companies such as Novo Energy, Spring Light Gas, Egoli Gas, and some others approved by NERSA (Audat, 2021).

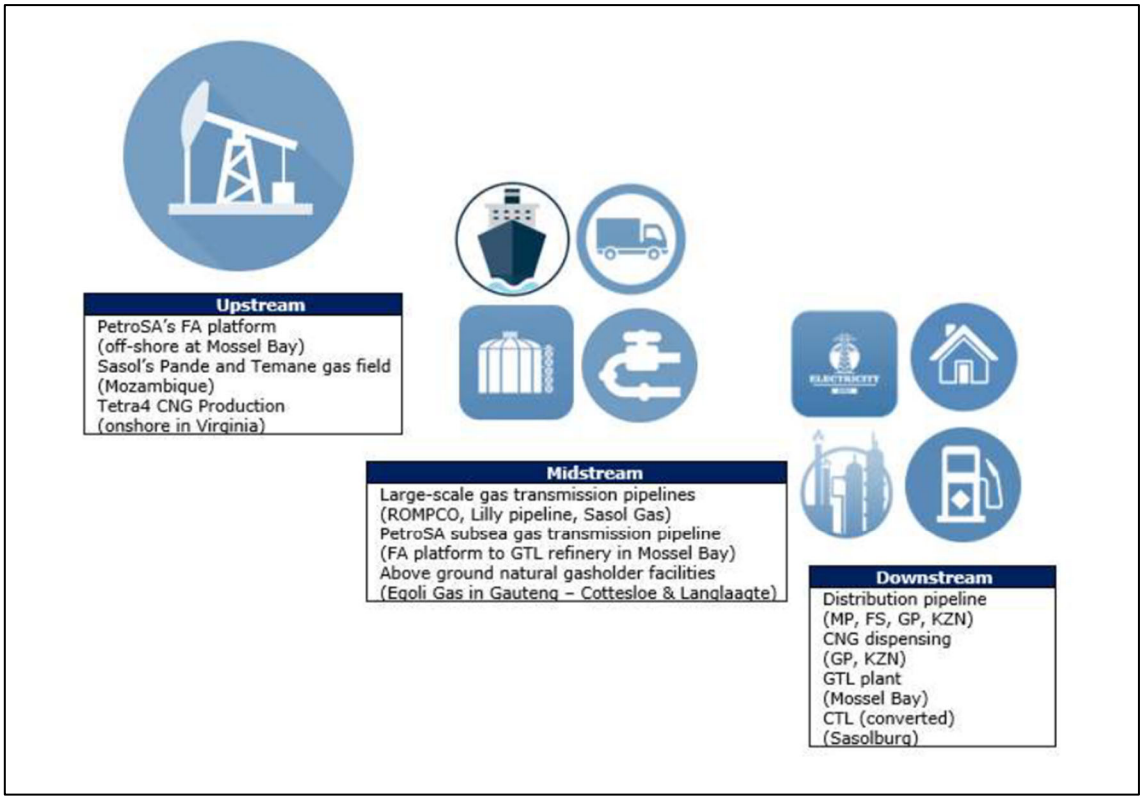


Figure 2.3: Natural Gas Value Chain

(Audat, 2021)

Despite the relatively small share of natural gas in the South African energy mix, the gas value chain here offers many opportunities. In a country like this with an extremely high unemployment rate, job creation is listed as a high priority. The gas value chain creates between 46,000 and 56,000 jobs and contributes approximately 1-2% to the overall South African GDP (Chaumontet et al., 2022).

The growth potential for natural gas in South Africa is expected to be high. There are four main sectors that drive this growth in demand; power, synfuels, industry, and transport (Chaumontet et al., 2022). These sectors contribute significantly to the GDP of South Africa, and growth in these sectors could stimulate economic growth that results in job creation.

2.4.1 *Proposition 2*

Natural gas is a strong option to consider in a national energy mix; it is supporting lower $C0_2$ emissions in an economy dominated by coal.

Globally, natural gas plays a major role in the energy mix. However, natural gas is a fossil fuel; it is a cleaner source of energy that supports global commitments to reduce C02 emissions and mitigate climate change and global warming. Although South Africa is still highly dependent on neighbouring countries to import natural gas, it could be used as an energy accelerator in the current energy transition of South Africa.

2.5 Research Question 3: Policies and regulations for natural gas in South Africa

Since 1994 the Republic of South Africa has become a federal state, and the country has become a fully multiracial democracy. In 1996, the Constitution of the Republic of South Africa came into effect (Eberhard, 2004). Transformation into a democratic federal state placed new emphasis on social equity, economic competitiveness, and regulatory controls. The new legislation focuses on reforming the economy and addressing the discrimination and inequalities of pre-1994. In the context of the political shift and the change in legislation in 1994, the electricity market of South Africa is reformed.

South Africa is also one of the countries with a highly regulated natural gas industry on a global scale. However, the enforcement remains weak. The gas industry is strictly regulated by the Gas Act of 2001, which falls under the South African National Energy Regulator (NERSA), and NERSA reports to the Department of Mineral Resources and Energy (DMRE). The Gas Act strongly supports and outlines the sustainable growth of natural gas in South Africa, with the aim of increasing the use of piped gas in communities and industries.

The well-defined regulatory framework is supported by a South African government committee. In 1998 the South African White Paper on Energy Policy was published and since then, the electricity sector of South Africa has gone through major transformations.

The White Paper states that

> *The development of the gas industry will stimulate inter-fuel competition, provide environmental benefits through lower emissions*

in contrast to coal and oil, provide greater option for industrial thermal applications, and increase the diversity of fuel supplies and hence improve South Africa's energy security (Department of Minerals and Energy, 1998).

The White Paper provides guidance on how to manage economic liberation to promote efficiency through free trade, deregulation, and privatisation of public services. This policy is considered the most important policy document in addition to the National Energy Act Nr. 34 of 2008, the National Energy Regulator Act Nr. 40 of 2004, and the Electricity Regulation Act Nr. 4 of 2006.

There have been more developments since the publication of the White Paper. In 2001, it was announced in a cabinet memorandum that 30% of the electricity generation can come from Independent Power Producers (IPPs). This was supported by the Integrated Resource Plan (IRP) that was successfully introduced in 2011.

Despite all the red flags raised and the urgency to reform the electricity market in South Africa, the South African government embraced state ownership. The process of reforming the electricity sector in South Africa has been slow, mainly due to political interest and fear of loss of control (Eberhard, 2004). The reform of the market in South Africa is arguably more the result of customers responding to a national electricity crisis than policies and strong regulation.

2.5.1 *Proposition 3*

The factors that impede the implementation of the South African national gas policy add to the causes of a limited and underdeveloped gas infrastructure in the country.

2.6 Conclusion of the Literature Review

Globally, $C0_2$ emissions are the main contributor to climate change and global warming, which could have devastating effects on humanity and the environment. The risks associated with climate change and global warming range from health risks, the collapse of glacier dams that cause major floods, and an increasing

number of deadly diseases. In 2015, the Paris Agreement was signed by 197 countries committed to mitigating climate change and striving to achieve net zero by 2050.

Among many other countries, South Africa is one of the signatories of the Paris Agreement and is committed to transform its energy mix by expanding less carbon-intensive power solutions. As discussed in this study, the purpose of the study was to investigate the role that natural gas can play in the energy transition of South Africa. The purpose includes recording possible solutions by answering research questions.

CHAPTER 3. RESEARCH METHODOLOGY

This chapter presents the paradigm of the research approach and strategy, how the research was conducted, and the method that was followed to address the proposition. The purpose of the study was to investigate how natural gas can play a role in accelerating the energy transition in South Africa.

3.1 Research Approach

The study followed a qualitative research approach to understand and investigate individual beliefs and insights. Qualitative research follows an interpretive social constructivist approach (Darby, 2019) as the research aims to understand the world in which we live and work while acknowledging the complexities of views and meanings (Creswell, 2018) as described. The specific context of these meanings was considered, as they are constructed socially. The researcher acknowledges her personal, cultural, and historical experiences and that such can shape interpretations.

Social constructivism has the right to a sociological analysis that includes scientific knowledge and science (Detel, 2001). Scientific knowledge is believed to be developed by social forces, and individuals must actively participate in the development of their own knowledge.

3.2 Research Design

Qualitative research can be defined as a discovery and a holistic approach in which data collection occurs in a natural setting and is sensitive to the people and places studied (Creswell, 2018). Qualitative research focuses on obtaining data from flexible conversations, seeking information, and investigating the whys and how they are related to the research questions (Creswell, 2018) Therefore, the findings are context dependent, and the viewpoints of the participants are considered (Williams, 2007). This approach allows the researcher to get a level of information from actual experiences (Williams, 2007) and focuses on gaining as much data as possible from a relatively small sample. It is known for its

flexibility, since participants can express themselves while simultaneously providing data. Qualitative design requires a commitment to a long period of time in the field and an often complex and time-consuming data analysis process.

For this research study, a phenomenological qualitative design was used, collecting information and experiences from participants. The aim with phenomenology design is to consider the viewpoints of participants and to take their pre-reflective experience into account (van Manen & Adams, 2010).

3.3 Data Collection Methods

Data were collected through semi-structured online and in-person interviews and allows for synchronicity that provides an opportunity for flexibility in terms of follow-up questions where the participants are actively involved in providing direction of the interview. The topics can therefore be explored in depth (Busetto et al., 2020).

In-person interviews were scheduled and planned so that the location was convenient for both the researcher and the participant. The participants selected for in-person interviews were based in the Gauteng province and therefore, the the cost of travel was kept as low as possible. In-person interviews have the advantage of having a better view and understanding of an individual's thoughts and opinions (Busetto et al., 2020).

On the other hand, online interviews are cost-effective, as no travel is needed and can be done at a time and virtual place that suit both the participant and the researcher. Another advantage of online interviews is that sessions are easily recorded, allowing one to refer to a section and store the recording on a safe online platform. The online interviews were conducted through MS Teams, where participants received an invitation to participate in the online interview. A disadvantage of online interviews is that participants may be unclear and inexact in answering the questions, and information could be lost with bad network connectivity.

The selected list of participants received invitations in advance, asking for permission and willingness to participate in the voluntary interview. It was easy to arrange in-person or online interviews with the participants since the selected participants are known to the researcher.

Seventeen selected participants were interviewed using an interview guide. The interview guide included four to five questions with a focused outcome and until saturation is reached. The participants were well informed before the interview. This ensured that the result of the interviews was effective and well-targeted.

3.4 Population and Sample

3.4.1 *Population*

Data for this research study were collected from a population of participants in the field, with a deep understanding and experience of the energy industry of South Africa. It included participants with a tertiary qualification and more than five years of experience in the oil and gas industry of South Africa.

Participants were selected from organisations that work and/or are actively involved in the oil and gas industry of South Africa or other African countries. They were personally selected by the researcher, ensuring that the participants are an accurate representation of the population.

3.4.2 *Sample and sampling method*

Convenience sampling was used in this research study. Because it is easy to collect data from a convenience sample, it is often used in qualitative research because of the ready availability of participants at a specific location. Participants who agree to participate in a convenience sample for a qualitative study usually have a motivation to participate, such as a specific interest in the topic, are eager to contribute or have very strong views and opinions on the topic (Stratton, 2021).

The selected sample consisted of 17 participants in the South African energy industry. It was assumed that this contains a sufficient population mix to collect

the needed data. Based on the level of experience and the job specification, the population consisted of people with at least five years of experience and a tertiary qualification. Participants with at least five years of industry experience are expected to have the necessary knowledge base to answer the questions. Assumingly, they also have the necessary exposure to the gas industry and understanding of the role that gas could or might play in the South African energy mix. The gender of the participants is listed to ensure that the responses are demographically representative.

Table 3.1: Profile of respondents

Nr	Industry	Organisation	Role of Participant	Years of Experience
1	Oil & Gas	Consulting	Project Manager	15
2	Oil & Gas		Design Engineer	6
3	Oil & Gas		Engineer	5
4	Oil & Gas		Project Manager	10
5	Oil & Gas	Construction	Construction Manager	20
6	Oil & Gas		Contracts Manager	10
7	Oil & Gas		Engineer	5
8	Oil & Gas		Director	20
9	Oil & Gas		Engineering Manager	20
10	Oil & Gas	Oil and Gas Producer	Developer	15
11	Oil & Gas		Investor	10
12	Oil & Gas	Academia	Specialist in the industry	20
13	Oil & Gas	Associations	Member	25
14	Oil & Gas	Government	Member	
15	Oil & Gas	Consulting	Environmental	
16	Oil & Gas	Academia	Specialist	
17	Oil & Gas	Gas distributor	Engineer	

To obtain accurate opinions and answers to the questions raised in this research study, participants were selected from five organisational groups as defined below.

- **Consulting**: Participants with a consulting background and experience in the oil and gas industry have a good understanding of the design complexities and limitations.
- **Construction**: Participants from a construction background have a good understanding and knowledge of construction challenges with respect to costs and other barriers.

- **Oil and gas producers**: Participants in the oil and gas markets should have a good understanding of the market and growth potential of the natural gas market in South Africa. These participants should also be able to provide insight into why the gas market in South Africa is relatively small.
- **Academia**: The participant from academia has a well-rounded academic background and knowledge base to validate the other views.
- **Oil and gas associations**: The participant selected from an accredited association could provide valid input into the policies and regulations that govern the South African natural gas industry.

3.5 The Research Instrument

An interview guide structured with numbered open-ended questions was used to collect qualitative data. The questions went from broad to narrow, and only one question was asked at a time. It was followed by facilitative communication techniques such as paraphrasing for clarity, summaries for member checking, reflecting on content, or minimal verbal responses to encourage further thinking or ideas.

The interview guide (Annexure A) was pre-tested with two participants to explore language, the clarity of questions, aspects of listening, and the researcher's skills with respect to interview technique (Cormac McGrath, 2019).

3.6 Procedure for Data Collection

The researcher identified the participants and then invited them for an interview by email. Online and in-person interviews with participants were scheduled on a day and time that were suitable for the individual participant. Each interview was about one hour long, unless otherwise arranged. This method allowed the researcher to understand and interpret the experience and perceptions of the participants. As the researcher is the key to data collection, the researcher personally conducted the interviews.

Each participant signed the following documents before the start of the scheduled interview.

- The informed consent form.
- A copy of the interview questions prior to the scheduled interview session.
- Background information and the purpose of the study.

Each session was only scheduled after the participant agreed and signed the forms.

3.7 Data Analysis and Interpretation

Data collected during the interview session with every selected participant were analysed using a thematic analysis. Therefore, the data were summarised and organised according to themes. The transcripts were read through, and codes were given to the meaningful segments. Similar segments were clustered into categories. Major, minor, and leftover themes were identified, and a preliminary analysis was constructed.

3.8 Limitations of the study

The following limitations of this qualitative research study are discussed below, including ways to mitigate the limitations in the best possible way. The interviews were planned primarily to be conducted in-person within an accessible area to limit travel costs. These in-person interviews might have been time-consuming and labour-intensive, and therefore, they were planned well in advance to avoid any loss of time. Participants were briefed prior to the interview to ensure effective and efficient participation. The researcher took care to ensure that the interviews were well organised and that the participants were well informed about the location, date and time of the interview.

Interpretation of data collected from selected participants could potentially be limited. The data collected and recorded from the selected participants are based on self-reporting by the researcher, and are available should the researcher need to revisit some of the recordings to verify the insights and knowledge gained.

3.9 Trustworthiness

3.9.1 *Transferability*

To ensure that the study is sufficiently descriptive and transferable so that the results and methods can be used in other settings or groups, the following strategies were employed: Participants were purposefully selected for their knowledge of the transformation of energy in South Africa, and thick descriptions of the context and transactions were written and communicated. The research study was conducted in a transferable manner to ensure that the findings and results could be used for similar studies. The transferability of this research study includes the criteria of applicability and relevance to fit with situations or research contexts like this research study (Krefting, 1991).Other African countries with a similar background, energy use and mix could benefit from the research study, hence the importance of ensuring the transferability of the research study.

3.9.2 *Credibility*

The credibility of the research study is supported by a well-considered list of participants that ensures that participants meet the criteria to ensure credible and valid results. Credibility was ensured through prolonged participation with sufficient time allocated to data collection activities. Online and in-person interviews were consistent in this manner, adding to the credibility of the data. Member checks were performed by checking information with participants during the interview, as well as sharing transcripts with participants afterward to review, validate, and verify information. To ensure reflexivity, a reflective diary was used where the researcher could reflect on feelings, judgements, and potential biases, should these arise (Krefting, 1991). Furthermore, the credibility of the research study is supported by the level to which the findings are applicable to other countries or situations (Krefting, 1991).

3.9.3 *Dependability*

Robust and detailed descriptions of the methodology are provided in the report to ensure a detailed audit trail. To ensure dependability, the findings are guaranteed and well recorded, even should there have been some changes in the research setting or with the selected participants. To enhance the dependability, a step-by-step method was described and followed, supporting visibility and traceability (Krefting, 1991).

3.9.4 *Confirmability*

All aspects of the study were fully recorded to allow for confirmation of the research findings. Interview transcripts are available to verify raw data for findings and the use of verbal quotes. Confirmability of the data was ensured by having all data available and stored in a secure online folder.

3.10 ETHICAL CONSIDERATIONS

Data collection was carried out strictly following the ethical guidelines of Wits University. Before data collection, the researcher submitted the research proposal to an ethics panel for approval, and collection was started only after ethical approval was obtained. All participants have the right to privacy, and in the event where any participant did not want their data to be shared, the data were treated as private. All evidence is stored in a confidential online folder to which only the researcher has access. Data will be destroyed after a specified period.

Participants had the right to fair treatment and were treated with respect. They had the right to stop the interview at any time. The researcher ensured that all participants understood the purpose of the study and signed an informed consent form prior to participating. The researcher also ensured that the participants understood when they signed the forms, that participation would be voluntary and without any remuneration.

3.11 CONCLUSION

This research study aimed to understand the causes of the limited and underdeveloped natural gas infrastructure in South Africa. Qualitative research was carried out to collect data from a selected sample of participants with industry-specific experience and knowledge. The findings of the qualitative research were context-dependent and largely based on viewpoints and insights from the participants.

The trustworthiness of qualitative research was ensured by considering transferability, credibility, dependability, and conformability. Qualitative research is mainly defined and depends on the views of people interacting in their own language and in specific terms (Krefting, 1991).

Table 3.2: Consistency table: research questions, propositions, data collection, and data analysis

RQ Number	Research Question	Prop	Proposition	Data Collection	Data Analysis Method
1	What are the main causes of the limited and underdeveloped gas infrastructure in South Africa?	1	The main causes of the limited and underdeveloped gas infrastructure in South Africa could be an abundance of coal supply and a limited or no need for a more developed gas infrastructure.	Interview guide	Thematic analysis
2	How is natural gas a strong option to consider in a national energy mix that supports lower CO_2 emissions in an economy dominated by coal?	2	Natural gas is a strong option to consider in a national energy mix, supporting lower CO_2 emissions in an economy dominated by coal.	Interview guide.	Thematic analysis
3	What factors are impeding the implementation of the national gas policy in SA?	3	Factors that add to the implementation of the national gas policy in SA.	Interview guide.	Thematic analysis

CHAPTER 4. FINDINGS AND DISCUSSION

4.1 Introduction

The purpose of this qualitative study was to investigate the role natural gas plays as an energy accelerator in the current energy transition of South Africa and was guided by the following research questions:

1. What are the main causes of the limited and underdeveloped gas infrastructure in South Africa, and could the supply of natural gas be one of the main causes?
2. How can natural gas be a strong option to consider in a national energy mix, supporting lower C0$_2$ emissions in an economy dominated by coal?
3. What factors are impeding the implementation of the national gas policy in SA?

To answer these questions, an interpretive social constructivist approach (Darby, 2019) was selected. Phenomenology, a qualitative design, was used to collect information and experiences from participants. This qualitative study was conducted using semi-structured online interviews. The questions asked in the interviews using an interview guide were aimed at getting information on the three research propositions that followed from the research questions.

The results of data collection and analysis are presented in this chapter.

4.2 Participant profile or demographical data

A sample of selected participants was invited for an interview. The use of interviews allowed participants to describe how they experience the natural gas industry in South Africa and to provide their points of view and insights. The sample consisted of 17 participants; however, saturation was reached by participant 14. To ensure that adequate and quality data were collected, the researcher collected data until redundancy occurred. After completion of the 14 semi-structured online interviews, no new insights were found, and the additional answers received from the participants were like those already obtained (Hennink

& Kaiser, 2022). With no new insights coming to light, the researcher concluded that saturation had been reached.

Of the 14 participants, 11 were men and three were women. All participants have more than five years of industry experience.

Table 4.1: Details of the 14 participants

Nr	Industry	Organisation	Role	Years of experience	Male/Female
1	Oil & Gas	Consulting	Director	15	M
2	Oil & Gas	Construction	Senior Engineer	12	M
3	Oil & Gas	Consulting	EC&I Engineer	7	M
4	Oil & Gas	Consulting	Civil Engineer	25	F
5	Oil & Gas	Consulting	Managing Director	42	M
6	Oil & Gas	Construction	Managing Director	40	M
7	Oil & Gas	Construction	Director	11	M
8	Oil & Gas	Consulting	Director	38	F
9	Oil & Gas	Association	CEO	30	M
10	Oil & Gas	Seller	Project Manager	15	M
11	Oil & Gas	Oil & Gas Producer	Investor	15	M
12	Oil & Gas	Oil & Gas Company	Engineering Manage	25	M
13	Oil & Gas	Oil & Gas Company	Engineering Manage	20	M
14	Oil & Gas	Consulting	Project Manager	13	F

4.3 Results pertaining to Proposition 1

Proposition 1 of this research study was to identify the main causes of the limited and underdeveloped gas infrastructure in South Africa and to determine if it was due to the abundance of coal supply and the limited, to no, need for a more developed gas infrastructure.

From the data collected through semi-structured online interviews of selected participants, responses were grouped into three themes. These three themes indicated three main causes for the limited gas infrastructure in South Africa, as discussed in the following section.

4.3.1 *Government Support*

More than half of the participants shared that they experienced a lack of support from government and regulatory bodies. The participants mentioned that the lack

of support from government includes funding and incentives. It was mentioned that support could be given by implementing tax breaks. Another outcome where more support could be given is to speed up the tedious approval process of permits.

They noted that the oil and gas industry in South Africa is heavily regulated but, at the same time, are offered limited support from regulatory bodies and the South African government. The main regulatory bodies overseeing the oil and gas industry of South Africa is the Department of Mineral Resources and Energy (DMRE), the Petroleum Agency of South Africa (SOC) and the Mineral and Petroleum Title Registration Office (MPTRO). These main regulatory bodies are supported by other important regulatory bodies including the National Energy Regulator of South Africa (NERSA). The participants also noted that there is often a lack of cohesion between these regulatory bodies. These bodies who are in control have limited mandates and have an isolated view, along with all the environmental applications, local community involvement, and logistical factors. The benefit of policies and regulation is that it protects South Africa and its resources against foreign corporations that will deplete these resources without sufficient compensation to the public.

The participants shared their frustration in dealing with different authorities. Among many frustrations are the different views and understanding of issues between authorities. Adding to the frustration is a lack of knowledge of natural gas and other gasses. Design and construction standards contradict each other, adding merit to the strongly suggested approach of having a centralised body that can take accountability ensuring the authorities speak from the same mouth.

A participant described this lack of harmony between energy sources and regulatory authorities as a major risk and that South Africa does not have a central body that drives and manages the energy mix. The risk explained by the participant is largely based on safety concerns and the importance of various energy sources that tie together to support existing and new infrastructures. Adding to the risk is the concern that the growth and development of each energy source is done in isolation, not considering how it technically fits together from a national point of view. Although the regulatory environment that supports the

growth and development of natural gas is large, there is a lack of integration and cohesion between the different authorities and regulating bodies. The natural gas value chain is regulated by different authorities at different stages of development. These stages of development refer to photographical surveys, exploration rights, and production rights. The participants felt that the different authorities with which they had to deal in different stages added to the inefficient management and approval of permits. The permits referred to by one participant were explained as specific applications throughout the gas value chain. In addition to the extremely time-consuming permit application process, dependent on the phase of the natural gas value chain, the South African government derives value from any oil and gas development. This makes the decision for any additional investment or development in the natural gas industry very hard. The input cost and time is very high with no to limited government funding, and only deriving value. The value is derived through taxes and royalties.

Of the respondents, 21% believed that the governing body for natural gas is cumbersome and that the country would benefit from having a single governing body. In addition to regulatory bodies, no single organisation or government department in South Africa is dedicated to the planning of natural gas as an energy option. Upstream oil and gas in South Africa are mainly regulated by the Department of Mineral Resources and Energy and the Petroleum Agency of South Africa.

Participants also shared their frustration that the Gas Master Plan is yet to be finalised. The South African Gas Master Plan Base Case Report was published in December 2021, and published for public comments in 2022. To date the Gas Master Plan has not been finalised or published, which confirms the finding that there is limited support from the South African government. Participants rely on the Gas Master Plan to outline and guide the development of natural gas in South Africa balancing supply and demand.

Participants believe that limited government support and lack of a finalised plan pose great challenges to the South African economy and energy security. Although there is a plan in place, the acceptance and implementation of the Gas Master Plan is inefficient and very slow progress is shown.

4.3.2 *Financial Investment*

Sixty-four percent of the participants shared their belief that lack of investment and funding from the South African government is another major cause of the limited and underdeveloped natural gas infrastructure in South Africa. South Africa is a relatively small country compared to developed countries in terms of energy usage and has developed so that its financial centres such as Johannesburg are in the inland. The development of gas infrastructure has been focused on these inland areas where economic activity is concentrated, particularly financial activities.

Some participants noted how the difficulty in obtaining international funding is negatively impacting the development of the natural gas infrastructure in South Africa. The funding needed for a larger natural gas infrastructure comes mainly from international sources. This is mainly due to limited public funding. However, the requirements and approval of international funding are high and unlikely, given the financial position and credit rating of South Africa. Besides financial stability, economic growth, and political situations are highly considered and finely analysed prior to large investments or funding.

According to the participants, the limited funding and investment available to enable the growth and development of the natural gas infrastructure is a large constraint that prevents the growth of natural gas.

4.3.3 *Supply of Gas*

Most of the participants shared the view that the limited availability and supply of gas to South Africa is a major cause of the limited and underdeveloped gas infrastructure in South Africa. Most of these participants are directly involved in gas-related cross-border agreements between South Africa and Mozambique and therefore, they understand the availability of natural gas. To date, the energy supply to South Africa is dominated by coal. Most of the participants had much to say about how dependence on coal hampered the exploration and exploitation of the gas energy option. South Africa is dependent on coal, not only for energy security but also for economic value and employment. The participants also noted

that maintaining dependence on coal as a primary energy source eliminated the need to develop and grow any other energy source, especially the development and funding of the natural gas infrastructure.

The participants pointed to the large coal deposits in South Africa. As a result of these large coal deposits, this resource is relatively cheap and reliable. South Africa is one of the largest coal producers and exporters in the world.

4.4 Results pertaining to Proposition 2

Proposition 2 of this research study was to establish how strong the option is to consider natural gas as part of the energy mix. All participants believe that natural gas is a strong option to consider in a national energy mix, supporting lower C02 emissions in an economy dominated by coal.

As explained by a participant, with an ageing coal fleet, gas projects can take up the MW deficit, as there is enough time before some coal stations are decommissioned to build new gas plants or retrofit existing coal plants. With more market penetration of natural gas power stations as well as infrastructure, the economy of scale applies, and it could become an established energy contributor. Natural gas is still a fossil fuel but produces considerably less carbon emissions than coal. Natural gas power generation also offers base load power in contradiction to the intermittency of renewables. Environmental, Social and Governance benefit as well as continuous power from feed stock that is available, energy providers will reap the benefits from natural gas.

The South African energy mix is still dominated by coal, and natural gas only forms 3% of the South African energy mix. Participants noted that for natural gas to play a greater role in the current South African energy mix, the market must be ready for it and the growth of natural gas must be supported by policies. The South African markets do not have an appetite for the gas option. They are still heavily dependent on coal due to the oversupply and affordable price. Alternative energy sources are limited, and the prices of these sources are still too high.

According to the insights collected from the study, natural gas should be considered a significant energy source for South Africa. The participants highlighted existing cross-border agreements between Mozambique and South Africa that support the importation of gas to South Africa.

All participants also highlighted that natural gas is more environmentally friendly than coal and oil alternatives. This agrees with the established fact that using natural gas for energy releases less C02 and other air pollutants into the atmosphere than coal or petroleum products for the same amount of energy (Natural Gas and the Environment – US Energy Information Administration (EIA), 2023).

Natural gas is a cleaner burning fossil fuel compared to coal and oil, emitting fewer greenhouse gases and pollutants when burnt (US Energy Information Administration, 2022). Natural gas plays a pivotal role in providing an effective bridge between traditional fossil fuels and renewable energy solutions (Mohammad et al., 2021).Participants also believe that incorporating natural gas as a bridge to renewable energy solutions is a strategic approach that ensures energy security and aligns with the government's goals to reduce emissions, foster economic growth, and position itself as a beacon of sustainable energy innovation.

Most of the participants also noted that gas-to-power plants have higher efficiencies and are quick to construct. Natural gas as an energy source offers flexibility and can manage load peaks more easily than coal-fired power plants. This is in line with findings from other research that point to gas-fired power plants being able to start up in a much shorter time span compared to coal-fired power plants (Glensk & Madlener, 2019).

The use of natural gas helps address fluctuations in the availability of power from renewable energy sources (Mac Kinnon et al., 2018).The continued use of natural gas in the transitioned energy mix improves energy security and mitigates the risks associated with disruptions of renewable energy supply. Participants believe that continued use of natural gas can also lead to a reduction in dependence on other less green fossil fuels.

The participants agreed that an important consideration to ensure energy security in the transition to carbon-neutral energy sources is energy diversity. Energy diversity refers to the use of a variety of energy sources to generate electricity. This approach of using various energy sources is important because it helps reduce dependence on a single energy source, which can be vulnerable to supply disruptions or price fluctuations (Kabeyi & Olanrewaju, 2022).Natural gas, along with renewables, provides a diverse energy portfolio that can meet varying energy demands, ensuring a reliable energy supply even during extreme weather conditions or unforeseen events. Participants believe that gas provides more energy security than other renewable energy sources.

Previous research highlights that renewable energy sources, such as wind and solar power, are variable in nature, meaning that their output can fluctuate depending on weather conditions (Robinson et al., 2021). Spikes in energy demand can cause the grid to overload, and thus negatively affect power quality (Ravi & Muhammad, 2022). Participants consider that due to the relatively quick startup times associated with natural gas power plants, it offers a suitable solution to balance power grids. Using natural gas infrastructure to balance the grid can ensure that it has a stable and reliable supply of electricity even as it transitions to carbon-neutral energy sources.

According to the participants, strong governance is needed before considering natural gas to be part of a larger percentage of the energy mix of South Africa. The participants explained and understood strong governance to be necessary for regulatory compliance, corporate governance, and accountability. Participants mentioned that in addition to governance, safety and risk must also be addressed.

4.5 Results pertaining to Proposition 3

Proposition three aimed to identify the factors that impede the implementation of the national gas policy of South Africa. From the data collected through semi-structured and structured interviews with selected participants, some factors are identified that impede the implementation of the national gas policy of South Africa. All participants in this study noted that challenges related to governance

and government capacity hindered the implementation of the national gas policy in South Africa. The challenges identified by the participants include conflicting ideologies, corruption, lack of capacity within the government and its institutions, and incompetence.

The South African natural gas industry is still highly regulated; however, the enforcement of regulations remains weak. There are four regulatory bodies responsible for monitoring the South African gas industry: DMRE, SOC, MPTRO, and NERSA. The participants stated that there is a lack of consistency between the requirements of these bodies and that there is little to no collaboration between them. The participants also noted that there is an apparent lack of cohesion on the directions, scope, and implementation of different policies surrounding the natural gas industry. Participants suggested that there is a need for a centralised body with a larger, integrated mandate.

Most of the participants also identified corruption as a hindering factor in the implementation of the South African national gas policy. This aligns with the broader trends observed in the literature, where many developing countries struggle with policy implementation due to corruption (TrishaRamsuraj & educorholdingsonmicrosoftcom, n.d.).The persistent presence of corruption in South Africa acts like a cancer, steadily corroding and subverting efforts aimed at socioeconomic development, alleviation of poverty, and promotion of good governance within the country (Ntoyanto, 2019) Participants suggested that stricter prosecution of corrupt officials would contribute to a better implementation of national gas policies.

According to some of the participants, the implementation of the national gas policy in South Africa is also impeded by the fact that the market is not yet mature enough due to the high dependence on coal. The participants encountered and observed a lack of capacity and no urgency within the government and its institutions to prioritise the implementation of the national gas policy. The main evidence is that most of the power in the country is generated by coal despite the provisions of the national gas policy that suggests a lack of urgency to build the gas infrastructure.

Many of the participants felt that there is also a high level of incompetence within government institutions. This lack of competence prevents the implementation of the national gas policy in South Africa. One participant defined incompetence as not having the correct industry experience paired with the correct tertiary qualifications.

Another factor impeding implementation is that natural gas falls under the larger umbrella of the Mineral and Petroleum Resources Development Act. A separate gazetted regulation on natural gas will ease implementation and speed up approval processes.

4.6 Summary

The limited and underdeveloped natural gas infrastructure is mainly due to three identified causes. These causes are limited government support, access to funding and investment, and the supply of natural gas.

Natural gas must be strongly considered as part of the South African energy mix, as well as a part of a larger percentage of the energy mix. Natural gas is more environmentally friendly than alternative coal and oil. Natural gas plays an important role in providing a bridge between traditional fossil fuels and renewable energy solutions.

Some factors are impeding the implementation of the national gas policy of South Africa, namely market maturity and the lack of a single governing body supporting the growth and development of natural gas in South Africa.

4.7 Comparison of the literature review and findings

Table 4. Comparison of the literature review and findings

RQ #	Research Question	Prop	State Proposition	Findings from own study
1	What are the main causes of the limited and underdeveloped gas infrastructure in South Africa?	1	The major causes of the limited and underdeveloped gas infrastructure in SA could be due to the abundance of coal supply and a limited, to no need for a more developed gas infrastructure.	- Limited support from the South African government. - Funding and Investment. - Supply of gas.
2	How is natural gas a strong option to consider in a national energy mix, supporting lower CO_2 emissions in an economy dominated by coal?	2	Natural gas is a strong option to consider in a national energy mix, supporting lower CO_2 emissions in an economy dominated by coal.	Natural gas is strongly considered. Cleaner fossil fuel. Bridge between fossil fuels and renewable energy.
3	What factors are impeding the implementation of the national gas policy in SA?	3	Factors that add to the implementation of the national gas policy in SA.	Market immaturity. There is no single governing body. Corruption and incompetence. Lack of knowledge.

CHAPTER 5. CONCLUSIONS & RECOMMENDATIONS

5.1 Introduction

This chapter includes the conclusions and recommendations of this research based on the findings that were discussed in Chapter 4.

5.2 Conclusions on Research Question 1

The first research question in this study aimed to identify the main causes of the limited and underdeveloped natural gas infrastructure in South Africa. From the data collected during the interviews with the selected group of participants, all respondents clearly agree that the main cause of the underdeveloped gas infrastructure in South Africa is due to the limited supply of natural gas. This finding suggests that efforts should be directed toward exploring and securing a more abundant and reliable supply of natural gas to meet infrastructure demands.

The lack of government support is another cause of the limited and underdeveloped natural gas infrastructure in South Africa. More than half of the participants argue that the South African government offers very limited support for the development and growth of natural gas in South Africa. This finding signals the need for policy makers to reassess and improve policies that encourage the development of natural gas infrastructure.

Furthermore, the lack of access to funding also plays a role in the underdevelopment of the gas infrastructure. Gas infrastructure is prohibitively expensive, not only in feasibility studies and designs, but also in construction. Policymakers and industry stakeholders may need to explore strategies to reduce costs, such as streamlining regulatory processes, incentivising private investment, or exploring more cost-effective construction methods.

5.3 Conclusions of Research Question 2

The second research question aimed to confirm that natural gas must be considered strongly as part of the energy mix. The participants in this study agree that natural gas should be considered in the national energy mix. Incorporating natural gas as a bridge to renewable energy solutions is a strategic approach that ensures energy security and aligns with the government's goals to reduce emissions, foster economic growth, and position itself as a beacon of sustainable energy innovation. Natural gas can also contribute to a more stable and resilient energy infrastructure, since its supply is more reliable and consistent compared to other renewable sources such as wind and solar.

Previous research points to natural gas playing a vital role in the transition from intense fossil fuels to renewable energy (Chaumontet et al., 2022). One of the key advantages of natural gas is its relatively low carbon intensity compared to coal and oil. Participants agreed that natural gas is an important consideration in the country’s energy mix to ensure energy security in the transition to carbon-neutral energy sources.

The participants in this study suggested that the incorporation of natural gas into the energy mix could promote economic growth. This economic growth can occur through various channels, such as creating jobs during the development and operation of natural gas infrastructure, infrastructure investments that stimulate economic activity, lower energy costs for businesses, and a stable and secure energy supply to attract businesses and investors.

5.4 Conclusions with respect to Research Question 3

With the third research question, the researcher aimed to understand what the factors were that impeded the implementation of the national gas policy in South Africa. Although the South African gas industry is heavily regulated, the finding shows that no single governing body assumes responsibility and accountability for the successful implementation and management of the national gas policy.

The participants stated that there is a lack of consistency between the requirements of different governing bodies and that there is little to no collaboration between them. With no governing body taking responsibility, there is no clear governance structure for overseeing and implementing the national gas policy. This can lead to confusion, inefficiencies, and difficulties in coordinating efforts among various stakeholders. A clear governance framework should be established that indicates the assigned responsibilities. Such a governance framework could improve the effectiveness of policy implementation.

Many of the participants felt that there is a high level of incompetence within government institutions. Creating a centralised authority that guides governance could lead to more effective resource allocation and higher levels of competency. This centralised authority could improve the efficiency of resource allocation and utilisation.

5.5 Recommendations

From the data collected for the purpose of this research study, gas clearly has a significant role to play in the energy mix of South Africa. Giving people access to reliable and cleaner energy presents opportunities for a better life and the creation of jobs.

It is recommended that the South African government considers a comprehensive restructuring of the regulatory body and the regulatory framework related to gas in South Africa. As seen from the data collected, although the gas industry in South Africa is still heavily regulated, it is still an inefficient and incompetent process. By eliminating government inefficiencies and lowering imposed taxes, natural gas development and investment will be more accessible and inviting.

5.6 Suggestions for further research

This qualitative research study investigated the causes of limited and underdeveloped natural gas infrastructure in South Africa. From the data

collected and summarised, the main causes are clearly due to the limited supply of natural gas.

Future research could aim to build a bankable FEED report, supporting and motivating international funding for the expansion of natural gas infrastructure and development in South Africa.

As a developing country, the South African energy industry still requires significant development. This pose opportunities for specialised companies to look at alternatives and mixed methods to grow the energy industry. More research can be done on green hydrogen and how this can be used in the energy mix of South Africa.

Further research can be conducted to include more participants from the public sector to understand the insights from the governmental side.

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Annexure A: Participant agreement form

Annexure B: Interview Guide

Annexure C: Permission Letter