DEPARTMENT OF MINERAL RESOURCES AND ENERGY

NO. 4760 **26 April 2024**

PUBLICATION OF DRAFT GAS MASTER PLAN, 2024 FOR PUBLIC COMMENT.

I, **SAMSON GWEDE MANTASHE**, **MP**, Minister of Mineral Resources and Energy, hereby publish the draft Gas Master Plan, 2024 for public comments.

Members of the public, stakeholders and industry experts are invited to submit inputs and/or comments on the Gas Master Plan by no later than **15 June 2024**. The draft GMP may be accessed on the departmental website and government gazette. Written comments may be addressed to the Director-General of the Department of Mineral Resources & Energy by:

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Sunnyside		Arcadia
0001		0007

Email address: GMP.Comments@dmre.gov.za

Kindly provide the name, address, telephone number, and e-mail address of the person and or/organisation when submitting the comments.

MR SAMSON GWEDE MANTASHE
DEPARTMENT OF MINERAL RESOURCES AND ENERGY
DATE: 11/04/2024

mineral resources
& energy
Department:
Mineral Resources and Energy
REPUBLIC OF SOUTH AFRICA

GAS MASTER PLAN 2024

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EXECUTIVE SUMMARY

South Africa is endowed with abundance of primary energy sources which are yet to be commercially developed to drive economic growth and social development. Fossil fuels such as coal, uranium, liquid fuels, and gas play a critical role in the socio-economic development of many countries globally. These primary energy sources must be commercialized in an environmentally responsible manner. Successful utilization of all possible energy sources for commercial purposes is vital for sustainable economic growth and development.

Energy security is a fundamental ingredient to a stable and growing economy. Government should focus on the key strategic objective of ensuring energy security, ensuring availability of energy resources and access to energy services in an affordable and sustainable manner, while minimising the associated adverse environmental impact.

The Gas Master Plan (GMP) adds to existing energy policies as we craft a roadmap towards an integrated energy planning approach. The gas plan outlines the role of natural gas within the context of energy mix and provides policy direction to industry. Upon final approval, it will provide a long-term gas energy infrastructure outlay, across the gas supply value chain.

Its scope is limited to upstream production and associated activities (excluding exploration) and midstream transmission networks (excluding reticulation).

The approach adopted by the Department in developing this plan was to model the likely development of the gas sector, based on projected gas demand as the country transitions from high-carbon emitting to low-carbon emitting technologies, whilst sustaining energy security to satisfy the energy profile of our industrialized economy.

Detailed results(outcomes) of this modelling exercise are contained in section 6 herein. Sub-section 6.5 provides details of sources of gas and required infrastructure to meet the projected inland and coastal demand.

1. INTRODUCTION AND BACKGROUND

The line function departments at the national level are mandated to develop sectoral policies, legislation and regulations, as required by the Constitution of South Africa. These sectoral policies are required to be aligned with the National Development Plan (NDP), with the overarching strategic vision being eradicating poverty, reducing inequality, and halving unemployment by 2030.

Chapter 4 of the NDP emphasizes that South Africa needs to devise policies and plans to improve the country's energy situation as well as alternatives to high carbon emitting energy technologies. Gas and renewable energy should be explored as one of the key policy instruments and planning priorities. The Department of Mineral Resources and Energy (DMRE) has a constitutional mandate to formulate and implement integrated mineral and energy policies that promote and encourage investment in the mining and energy sector.

The prevailing legislation in the gas sector is the Gas Act (Act No. 48 of 2001). The objectives of the Act are aligned with the 1998 White Paper on Energy Policy. The Act also establishes a national regulatory framework for the piped gas industry in South Africa and facilitates investment in the gas industry.

At the time of development of the Gas Master Plan (GMP), the Act was undergoing amendment. The Amendment Bill seeks to address shortcomings, omissions, and other challenges experienced during implementation of the Act. Thus, the Bill is expected to strengthen enforcement and improve compliance by the gas sector.

The GMP recognises South Africa's abundance of primary energy sources which, if commercialized, could drive economic growth, social development and thus benefit the country. Fossil fuels such as coal, uranium, liquid fuels, and gas play a critical role in the socio-economic development of the country. Government is committed to processing these minerals in an environmentally responsible manner, whilst ensuring security of energy supply. Successful utilization of all possible energy sources for commercial purposes is vital for sustainable economic growth and development.

Energy security is fundamental to inclusive economic growth. Government should focus on the key strategic objective of ensuring energy security, and thus ensure availability of energy resources and access to energy services in an affordable and sustainable manner, while minimising the associated adverse environmental impact.

The GMP adds to existing energy policies, as the country transitions to an integrated energy planning approach.

2. GAS MASTER PLAN IN CONTEXT

2.1 Objectives of the Gas Master Plan

The GMP outlines the role of natural gas within the context of energy mix and provides policy direction to industry. The plan considers the critical role that natural gas can play in the country's entire economy and projects the anticipated infrastructure necessary for the provision of gas, on a least cost basis, to the power, industrial and transport sectors. The plan provides a long-term gas energy infrastructure outlay, and is a multi-faceted plan, intended to achieve the following multiple objectives:

- Ensure that gas supply is secured by diversifying supply options from both local and international markets, while minimising the total supply costs and foreign currency exposure. Supply projections are based on future anticipated demand.
- Facilitate an efficient, competitive and responsive energy infrastructure network (gas storage facilities, liquefied natural gas (LNG) import facilities, pipeline network and regasification plants) that will enhance localisation, while at the same time creating jobs and growing the economy.
- Identify strategic partners in the Southern African Development Community (SADC) to unlock local and regional gas demand.
- Ensure that environmental assets and natural resources are protected and continually enhanced by cleaner energy technologies.
- Determine resilient gas infrastructure options in the light of demand uncertainties and the possibility of a later transition to cleaner fuels.

The GMP serves as a policy instrument, providing a roadmap for strategic, political, and institutional decisions, which will guide gas industry investment planning and coordinated implementation.

A growing gas economy is likely to improve security of energy supply through diversification of the energy sources that the economy relies on for growth. Natural gas, as a source of energy production, could also alleviate the pressure on electricity supply demand in the short to medium term, as electricity consumers will have options to switch to natural gas as an input into their operations.

The GMP will ensure that the country's natural gas demand is well managed, and that the broader energy supply is secured once natural gas is enabled as a viable option from both the local and international markets, while minimising the total energy cost to the economy. This in turn will facilitate an efficient, competitive, and responsive energy infrastructure network (gas storage facilities, LNG import facilities, pipeline network and regasification plants) that will enhance localisation, while at the same time creating jobs and growing the economy.

2.2 Scope of the GMP

The GMP traverses the upstream, midstream, and downstream gas value chain components.

The scope of the plan is limited to upstream (excluding exploration) and midstream transmission networks with the exclusion of downstream (reticulation) value chains.

The plan considers the upstream, midstream and downstream natural gas topology, from gas supply/production infrastructure and gas importation infrastructure to midstream transmission networks and downstream distribution networks.

2.3 Role of Gas

Natural gas commercialization has brought significant changes to most countries resulting from capital investment in gas infrastructure and revenue derived from commodity export. Other countries, notably small producers, have used their natural gas, coupled with gas imports, as a fuel to increase electricity generation. Countries using gas as an input energy source for power generation have seen their electricity production grow about three (3) times faster in the past ten (10) years than those that are not able to use gas[1].

Natural gas is one of the mainstays of global energy. It has several commercial applications in the power, large industry and transport sectors. Natural gas is grouped amongst the cheapest forms of energy available to residential consumers where infrastructure to deliver such gas is in place. It is also the cleanest burning and fastest growing fossil fuel (IEA, 2021). Worldwide, consumption of natural gas is rising rapidly, accounting for about a quarter of global electricity generation and for almost half of the growth in total global energy demand in 2018 (IEA, 2021).

In 2020, South Africa joined other first world country leaders[2] in announcing a historic partnership to support a just transition to a low carbon economy and a climate resilient society. South Africa has thus committed to gradually move towards lower carbon technologies while ensuring that society, jobs and livelihoods are not negatively impacted, especially in a country where the majority (approximately 90%) of electricity generation is from coal.

Natural gas can be used to support the reduction of emission pollutants into the atmosphere. The clearest case for switching from high-carbon emitting technologies to gas emerges when it is possible to use existing power generation infrastructure to provide the same energy services, with lower carbon emissions. The main area for competition between unabated coal and gas in the United States and Europe has been electricity generation, as the switching calculation for gas and coal changes across different parts of the energy sector[3]. This form of switching is also proving to be a solution for customers in sectors that are difficult to decarbonise, such as the construction, iron and steel industries.

Natural gas-powered industrial applications offer a variety of environmental benefits and environmentally friendly uses that include fewer emissions, reburning, reduced sludge and co-generation. In electricity generation, natural gas is used in steam generation units, centralized gas turbines, combined cycle units, locomotives, distributed generation, industrial natural gas fired turbines, micro turbines and fuel cells.

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[1] African Energy Commission (AFREC). (July 2021). Natural Gas in the African Energy Landscape. A Special Policy Report on Energy

[2] France, Germany, United Kingdom and United States as well as the European Union

[3] International Energy Agency. (2019). The Role of Gas in Today's Energy Transitions

Among the end-use sectors, industry is a major contributor to the projected growth in gas demand. Natural gas has a clear competitive advantage in industrial applications where it displaces more costly fossil-based energy sources[4]. In the transport sector, natural gas can provide an alternative to oil products for passenger, freight and maritime uses. Most of the gas used in buildings today is for space heating, although other end uses, such as cooking and water heating, are increasing in importance.

In the United States, gas is predominantly used by the residential cluster for space heating and cooking due to its cost being approximately half that of electricity, and the fact that it is also relatively simpler to store and heats quickly. Natural gas is historically the most popular fuel for residential heating. In 2000, fifty-one percent (51%) of the heated homes in the US used natural gas according to the American Gas Association (AGA)[5]. Natural gas is often used in commercial industrial buildings for space heating, water heating and cooling purposes. Natural gas also provides base ingredients for products such as plastics, anti-freeze and fabrics.

Although applications for natural gas vary across economic sectors, the focus of the GMP is limited to the provision of gas to meet demands projected in the power, industrial, and transport sectors. Within these large consuming sectors, it is evident that natural gas can bring environmental benefits. However, there is no single solution to turn emissions around; multiple approaches, policies, and technologies will be required at different times.

The 1998 White Paper seeks to ensure security of energy through diversification of both supply sources and primary energy carriers. In certain timeframes and sectors, switching from more polluting fuels to gas can play an important role. Natural gas is considered a transition fuel from unabated coal as the world attempts to replace emission-intensive fossil fuels such as unabated coal and diesel.

In the South African context, natural gas can play a significant role alongside the rise of renewable energy, improvements in energy efficiency and a more balanced, cleaner energy mix in reducing power sector emissions.

3. GAS DEMAND

3.1 Gas Demand Scenarios

The demand gas projections presented in the study are dictated by a gas network topology of the country, as most of natural gas consumed in the country is imported piped gas from Mozambique. Though it is generally accepted that large shale gas resources of between 19 tcf and more than 400 tcf potentially

[4] International Energy Agency. (2019). The Role of Gas in Today's Energy Transitions

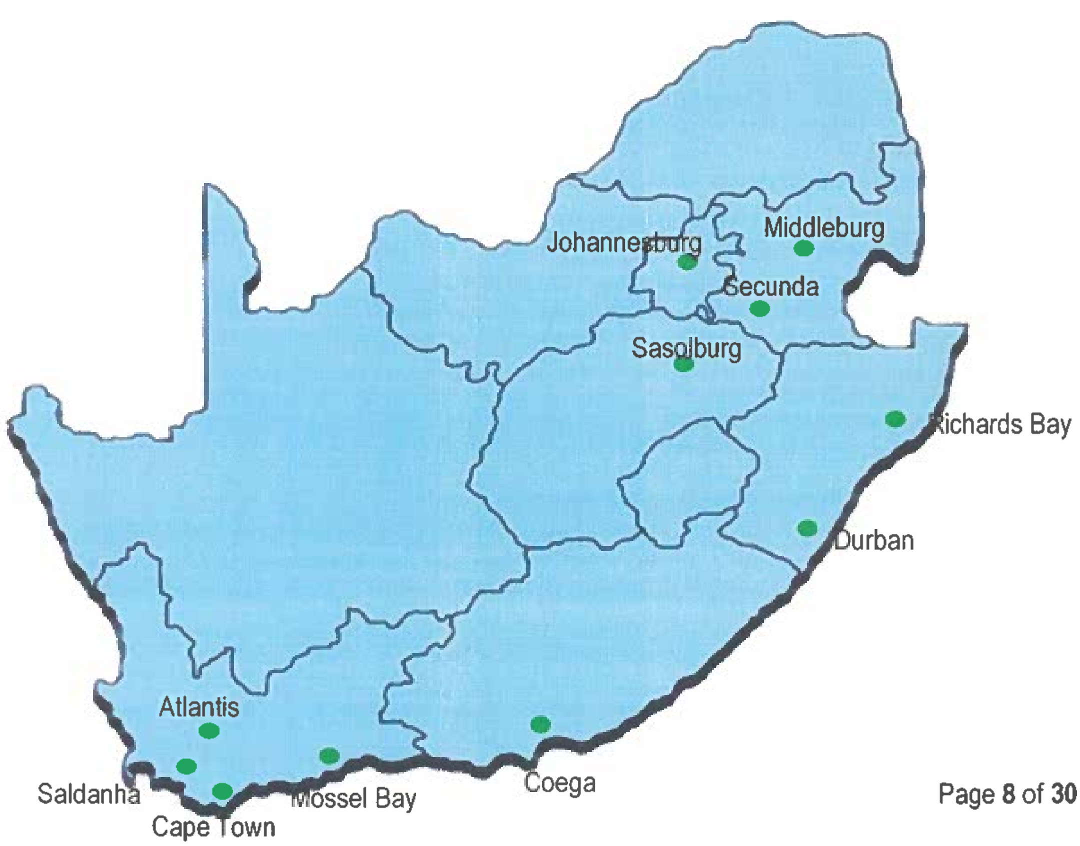
[5] Fang-Yu Liang, Marta Ryvak, Sara Sayeed, Nick Zhao. The Role of Natural Gas as a Primary Fuel in the Near Future, Including Comparisons of Acquisition, Transmission and Waste Handling Costs of Gas with Competitive Alternatives

exist in the Karoo area, these reserves are yet to be proven. Until the reserves are proven and processed into consumable gas, South Africa remains a gas importing country and thus the demand projections presented in this section will likely drive import infrastructure along the coastal area of the country to facilitate importation of gas in the short to medium term.

Table 1: Identified Gas Demand Nodes

Demand Node	Description
Atlantis	Conversion of Ankerlig power station
Coega	New-builds, conversion to gas-fired power stations, potential industrial switching to natural gas
Cape Town	Conversion to gas-fired power stations, potential industrial switching to natural gas
Durban	Industrial gas consumption
Johannesburg	Industrial gas consumption and conversion of old power stations
Mossel Bay	Industrial gas consumption and conversion to gas-fired power stations
Middleburg	Industrial gas consumption and conversion to gas-fired power stations
Richards Bay	New-builds, conversion to gas-fired power stations, and potential industrial gas consumption
Saldanha Bay	New-builds and potential industrial gas consumption
Sasolburg	Industrial gas consumption and private gas-to-power generation
Secunda	Industrial gas consumption and private gas-to-power generation

Figure 1: Graphical Representation of Demand Nodes



Three (3) gas demand scenarios are considered in our demand growth analysis. These are (i) low demand growth, (ii) medium demand growth and (iii) high demand growth scenarios. In each scenario, gas demand is largely driven by power sector in the gas to power. Tables 2 to 4 summarize the technical characteristics parameters per demand scenario.

Natural gas demand within the power sector is driven by five (5) initiatives, namely *(i)* conversion of Open Cycle Gas Turbine (OCGT) to Combined Cycle Gas Turbine (CCGT) power stations, *(ii)* full implementation of IRP2019, *(iii)* implementation of the Risk Mitigation Independent Power Producer Procurement Programme (RMI4P), *(iv)* Eskom granted determinations and *(v)* conversion of Eskom's retiring coal power stations.

All the Independent Power Producer (IPP) new builds assume an operating load factor of fifty percent (50%) and efficiency rates of thirty-nine percent (39%). Eskom's peaking power stations assume an operational load factor of twelve percent (12%) and efficiency rate of fifty-five (55%) while its new builds and coal-to-gas conversions assume the operating mid-merit load factor of forty-eight percent (48%) and an efficiency rate of forty-eight percent (48%). The three scenarios provide allocation of installed capacities and parameters per demand node.

Table 2: Power Sector Assumptions for Low Gas Demand Scenario

Demand Node	**Installed Capacity (MW)**	**Load Factor (%)**	**Efficiency Rate (%)**
Conversion of OCGT to CCGT power stations:			
Mossel Bay (Gourikwa)	746	12	55
Atlantis (Ankerlig)	1 338	12	55
Total Installed Capacity (2 nodes)	**2 084**		

Two (2) power stations, Ankerlig in Atlantis and Gourikwa in Mossel Bay, are included in the low gas demand scenario. They are assumed to run at a peaking load factor of 12% as stated in IRP2019. An improvement in efficiency rate of 55% is assumed in this scenario due to conversion from OCGT to CCGT power generation.

Table 3: Power Sector Assumptions for Medium Gas Demand Scenario

Demand Node	**Installed Capacity (MW)**	**Load Factor (%)**	**Efficiency Rate (%)**
Conversion of OCGT to CCGT power stations:			
Mossel Bay (Gourikwa)	746	12	55
Atlantis (Ankerlig)	1 338	12	55
New build as a result of IRP2019:			
Coega (IPP)	1 000	50	39
Middleburg (IPP)	2 000	50	39
New build as a result of RMI4P:			
Richards Bay (IPP)	450	50	39

Demand Node	**Installed Capacity (MW)**	**Load Factor (%)**	**Efficiency Rate (%)**
Coega (IPP)	650	50	39
Saldanha Bay (IPP)	320	50	39
New build as a result of Eskom's determination:			
Richards Bay (Eskom)	3 000	48	48
Conversion of Eskom coal to gas-fired power stations – Decommissioning in IRP2019:			
Middleburg (Komati)	1 000	48	48
Total Installed Capacity (6 nodes)	**10 504**		

The power sector assumptions in the medium gas demand scenario incorporate the same assumptions as in the low gas demand scenario, including additional new builds through the government-driven IPP programme, Eskom Section 34 determination acquired and conversion of Eskom's old coal-fired power stations that are due for decommissioning to gas-fired power stations as per IRP2019.

Eskom's new gas-fired power stations are assumed to run at a mid-merit load factor of forty-eight percent (48%) and a plant efficiency rate of forty-eight (48%) while its peaking power stations are assumed to run at a peaking load factor of twelve percent (12%) and an improved plant efficiency rate of fifty-five percent (55%). Government's IPP programme is assumed to run at a mid-merit loading factor of fifty percent (50%) and an efficiency rate of thirty-nine percent (39%).

Table 4: Power Sector Assumptions for High Gas Demand Scenario

Demand Node	**Installed Capacity (MW)**	**Load Factor (%)**	**Efficiency Rate (%)**
Conversion of OCGT to CCGT power stations:			
Mossel Bay (Gourikwa)	746	12	55
Atlantis (Ankerlig)	1 338	12	55
Durban (Avon)	670	12	55
Coega (Port Rex)	171	12	55
Coega (Dedisa)	335	12	55
Cape Town (Acacia)	171	12	55
New build as a result of IRP2019:			
Coega (IPP)	1 000	50	39
Middleburg (IPP)	2 000	50	39
New build as a result of RMI4P			
Richards Bay (IPP)	450	50	39
Coega (IPP)	650	50	39
Saldanha Bay (IPP)	320	50	39
New build as a result of Eskom's determination:			
Richards Bay (Eskom)	3 000	48	48
Conversion of Eskom coal to gas-fired power stations – Decommissioning in IRP2019:			
Middleburg (Komati)	1 000	48	48
Middleburg (Hendrina)	2 000	48	48
Middleburg (Camden)	1 600	48	48
Middleburg (Grootvlei)	1 200	48	48
Total Installed Capacity (8 nodes)	**16 651**		

The medium and high gas demand scenarios share the same technical assumptions in relation to load factor and efficiency rate, the main difference being the magnitude of assumed total installed capacity. The medium scenario assumes a total gas-to-power installed capacity of 10 504 MW while the high scenario assumes 16 651 MW.

4. GAS SUPPLY

4.1 Gas Supply Approach

The objective of modelling the natural gas system is to find the most economical mix of gas supply and infrastructure to ensure the best possible route to deliver natural gas to users over the planning horizon 2023 to 2050. The model is long-term in nature, and should therefore *minimize long-term* system costs, which comprise of:

- Production cost of the gas fields
- LNG import costs
- Building and operation costs of LNG receiving and distribution infrastructure
- Building and operation costs of the gas transportation system

The model is constrained to the following daily/annual limits:

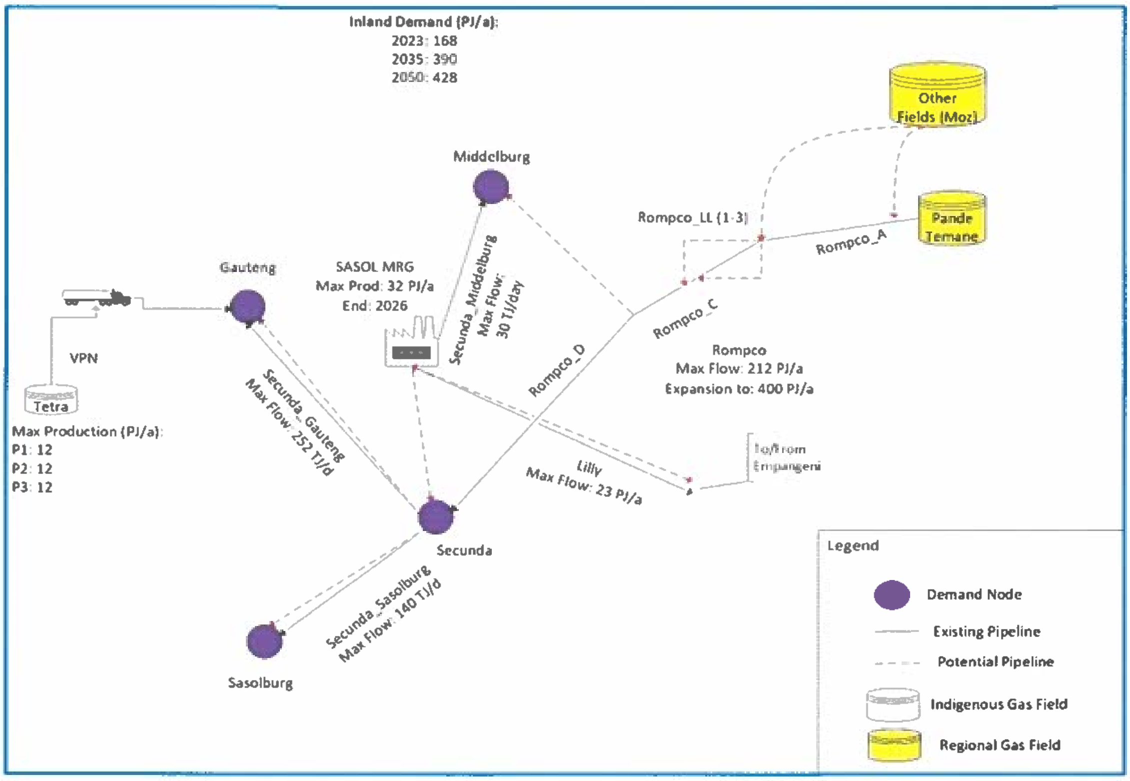
- Production: Annual/daily production limit from the fields
- Storage: Capacity and maximum withdrawal rate
- Transportation: Maximum flows

The model is steady state and shows the balances over time (no imbalances). The following was the approach in modelling the components of the natural gas system:

Gas Topology:

To understand possible gas supply options for the identified demand nodes, it is necessary to analyse the "*as is*" supply-transportation-consumption topology. Figure 2 depicts the existing gas topology in South Africa. Potential new infrastructure, necessary to meet the projected demand, is shown in red. Figure also shows possible paths that the gas could follow to meet the demand. The model's objective is to determine the path of least cost.

Figure 2: Gas Topology



Modelling Approach

Gas Fields:

The production from the new gas fields was gradually ramped up in the first three (3) years of production to the plant capacity. Methane-rich gas (MRG) that is dedicated to demand in KwaZulu-Natal will stop from 2027 and be used for Sasol's own use.

LNG Terminals:

For this modelling plan, the configuration reflected in Table 5 was used. The Floating Storage Regasification Unit (FSRU) for the RMI4P was modelled with a lease option and a fixed contract of seven (7) years, without competing with any other options. From 2030, this FSRU was allowed to compete with the other three options from each port, with Regional import still an option. The model was limited to choosing either to lease an FSRU or build a conventional onshore terminal at each of the proposed ports.

Table 5: LNG Technologies Timelines Configuration

Technology	Sizes (m3)	Year							
		2023	2027	2029	2030	2035	2040	2045	2050
Regional (Onshore or FSRU: Lease)[6]	125 000 - 170 000								
RMI4P (FSRU: Lease) RB, SB, NGQ	125 000								
Technology: Lease/Buy/Onshore – RB	170 000								
Technology: Lease/Buy/Onshore – Ngqura	125 000								
Technology: Lease/Buy/Onshore – SB	125 000								

Storage:

As natural gas demand is aggregated per year, the model uses a step size of one year. This approach is accurate for annual volume calculations as there are no demand fluctuations within the annual time-period.

Pipeline Infrastructure:

The transportation cost in existing pipelines is given as a tariff (R/GJ) and is modelled as flow charge which represents capital recovery on deployed assets. It is assumed that this tariff also include any compression that is required and therefore compression costs for existing pipelines are not shown explicitly.

Compressor and Fuel:

Compression costs, including associated fuel costs, are included in the total cost of pipeline.

Pipeline Size:

The model can build different pipelines of sizes (diameters) – 12, 16, 20, 24, 30 and 36 inches. Only one (1) pipeline diameter is allowed between two (2) nodes. Thus, the model assumes the same size for the full length of the pipeline.

Gas Demand:

The cost of unserved demand was set to a high value to force the model to satisfy the demand when the supply source is available. This is in line with the objective of determining the cost of satisfying the total demand.

[6] Regional options are not restrictive to LNG only. Other fields could offer better supply opportunities.

5. BASE CASE AND CONSIDERED SCENARIOS

This section covers four (4) scenarios to be considered in the development of the GMP, namely *Scenario 1*: Base Case, *Scenario 2*: Indigenous Gas Priority, *Scenario 3*: Regional Integration, and *Scenario 4*: Gas as a Transitional Fuel. These scenarios are categorised into projected demand growth scenarios and key input scenarios. A brief description of each scenario is outlined below.

5.1 Scenario 1: Base Case/Reference Case

The base case/reference case scenario assumes medium gas demand growth from the power sector and non-power sectors, as outlined in the demand scenario. It uses only the short-term fields as described in the scenario table.

Additional Modelling Information I: LNG from USA, Australia, Qatar and Nigeria.

5.2 Scenario 2: Indigenous Gas Priority

Gas demand is assumed to be lower under the indigenous gas priority scenario. To reduce the supply options, indigenous gas fields should be prioritised to deal with the lower demand. That is, as soon as the indigenous fields become available in the medium term, they should replace some of the LNG imports. This thus means that contracts should be flexible to allow for lower import volumes in the medium term when compared to the short-term base case.

The AE Mpumalanga field and Lephalale CBM are options that could contribute to the indigenous gas fields when their data becomes available.

5.3 Scenario 3: Regional Integration

Unlike in the base case, where LNG is assumed to be coming from established markets, in the regional integration scenario, global gas should be supplemented by gas from within the region. In other words, LNG imports, which were coming from established markets should be replaced with LNG from regional markets such as Namibia and Mozambique to take advantage of their proximity. Leasing contracts should therefore be short-term to allow for switching.

Additional Modelling Information II: Replace US, Australia, Qatar and, Nigeria with regional markets.

Regional import piped-gas will be considered to supplement (or replace) Regional LNG option as data becomes available.

5.4 Scenario 4: Gas as a Transitioning Fuel

Under this scenario, gas usage grows at a higher rate, plateaus for a period and then reduces in later years. The demand for natural gas reduces as innovative fuels such as hydrogen are introduced to reduce net GHG emissions. Hydrogen, however, has a lower energy content than natural gas, therefore more hydrogen will be required to yield same energy output. This could imply a lot more infrastructure expansion.

For Scenario 4, the fields considered are all the high demand field scenarios. Beyond gas plateau period, the infrastructure built, such as onshore storage terminals and pipelines, can continue to be used even after transitioning, with some modifications, to cater for alternate fuels such as hydrogen.

The four (4) proposed scenarios are summarised and categorized in Table 6 with key input parameters and projected demand growth.

Table 6: Summary of the Scenarios

Sectors/ Supply sources	Drivers	Value/Description	Basecase/ Reference Case	Indigenous Priority	Regional Integration	Gas as a Transitional Fuel
Demand	Low Demand			x		
	Medium Demand		x	x	x	
	High Demand					x
Supply fields	Short term	Pande Temane, Tetra, Block 11B/12B Phase 1, Block 2A	x	x	x	x
	Medium term	Lephalale CBM		x	x	x
	Long term	Shale gas, AE Mpumalanga, Offshore Frontiers		x	x	
Production costs $/GJ (R/GJ)	Low Indigenous Production cost	4 (69)				
	Mid Indigenous Production cost	6 (104)	x	x	x	x
	High Indigenous Production cost	8 (138)				
Regional Est. Landed Prices $/GJ (R/GJ)	Regional Landed Prices (SB)	13.43 (232.11)		x		
	Regional Landed Prices (Ngqura)	13.97 (241.41)		x		
	Regional Landed Prices (RB)	13.87 (239.67)		x		
International Est. Landed Prices $/GJ (R/GJ)	International Landed Prices (SB)	14.04 (242.57)	x			
	International Landed Prices (Ngqura)	14.24 (246.15)	x			

	International Landed Prices (RB)	14.13 (244.09)	x			

6. RESULTS ANALYSIS

This section presents the modelling results, based on least-cost optimisation, for the period 2023 to 2050. It covers the indigenous production fields, LNG imports, port terminal infrastructure and transporting networks. The purpose of optimizing these natural gas upstream options is to meet projected increasing demand, at a least cost possible.

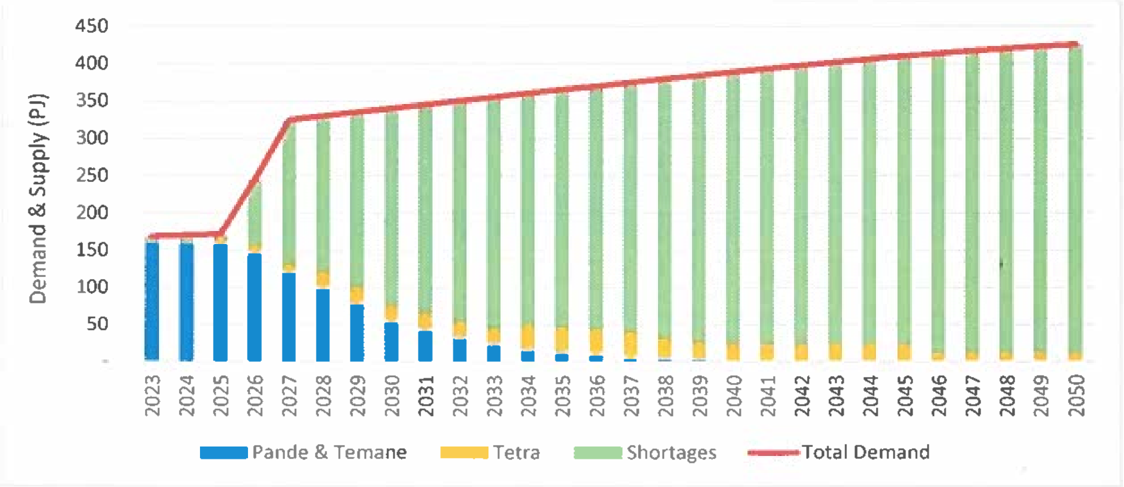
6.1 Natural Gas Shortages Before Optimization

An overview of both demand and supply assumptions before optimization is provided herein. When analysing the demand projections and available supply options, a substantial shortage is observed. The objective of modelling is thus to find possible ways to eliminate the shortages whilst reducing possible infrastructure cost. To do this, the natural gas shortages were analysed as two (2) groups, namely inland and coastal shortages.

6.1.1 Inland Shortages

Given the demand and supply assumptions, the estimated maximum production rates from indigenous fields are insufficient to satisfy projected demand over the base case scenario planning horizon. Figure 3 depicts the inland natural gas shortages.

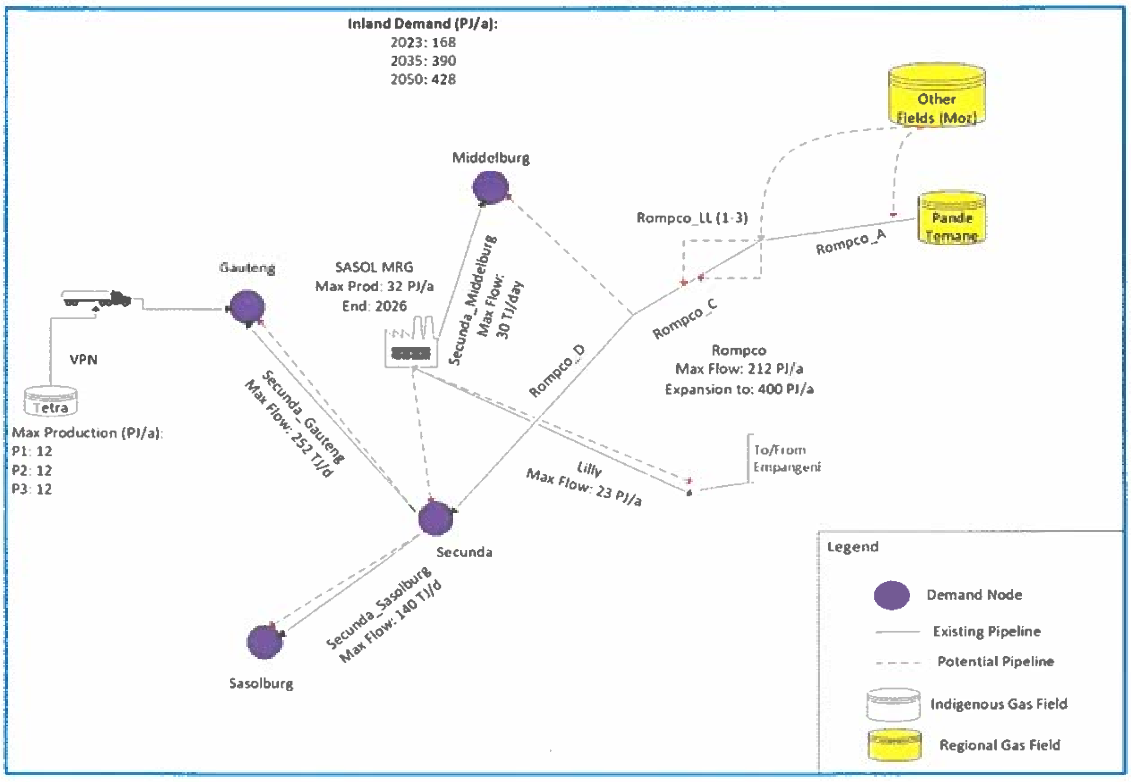
Figure 3: Inland Shortages



As illustrated in Figure 4 below, inland demand is the aggregated demand for Gauteng (Johannesburg and Pretoria), Sasolburg, Secunda and Middelburg. A portion of the demand for Secunda will be serviced by Sasol Methane Rich Gas (MRG) from 2027 when the company ceases to supply its existing customers in KwaZulu-Natal and Middelburg. The Secunda demand would thus increase, which would result in Secunda being the highest consuming demand node in the base case/reference case scenario.

Figure 4 also shows the associated infrastructure, as well as potential supply sources for the inland demand nodes. The current sources are Pande and Temane through the ROMPCO pipeline and Virginia (Tetra) through a Virtual Pipe Network (VPN), while the potential supply could be from other adjacent sources within Mozambique, injecting into the ROMPCO pipeline, and the Richards Bay terminal through the reversal of Lilly pipeline and/or a parallel potential pipeline. Regional LNG could also be considered as an option for potential supply; however the supply becomes non-viable as it competes with other potential injections into ROMPCO.

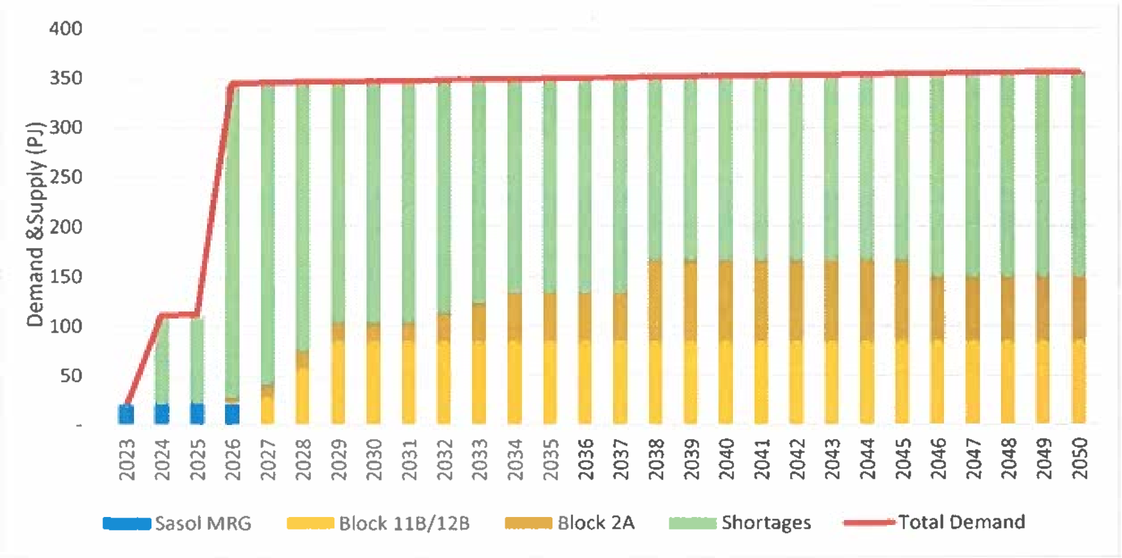
Figure 4: Inland Topology



6.1.2 Coastal Shortages

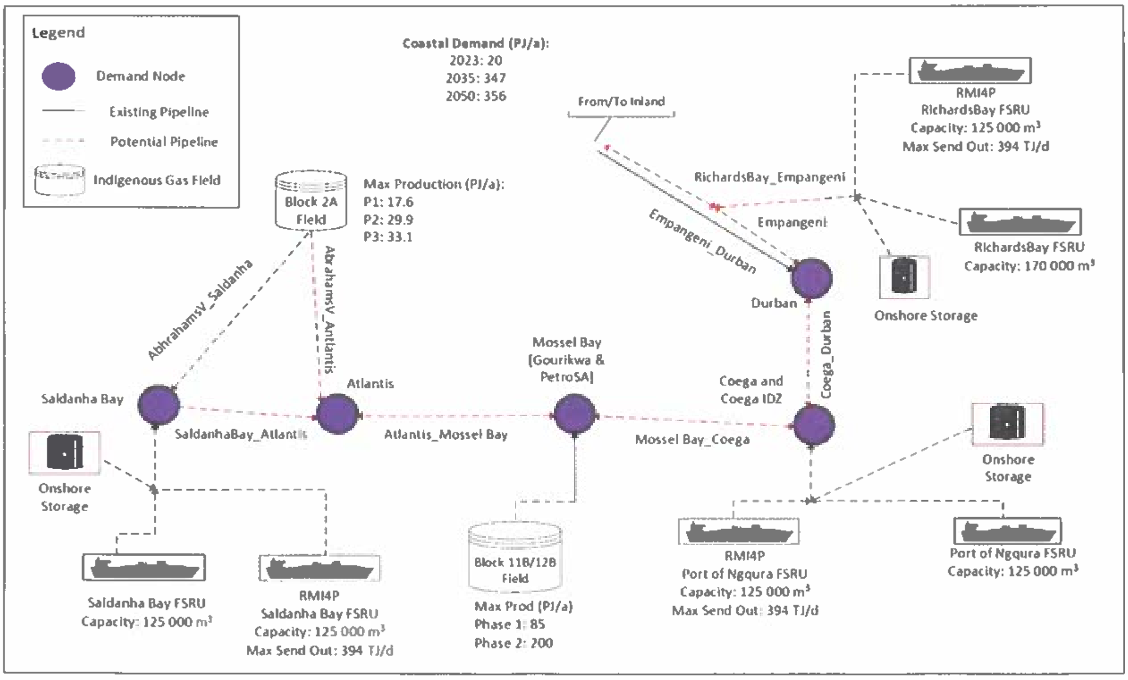
The total coastal demand, as shown in Figure 5 below includes Risk Mitigation Independent Power Producer Procurement Programme (RMI4P) power demand in Richards Bay, Ngqura and Saldanha Bay as well as IRP 2019 power demand at Coega and Middleburg (assuming reversal of Lilly pipeline).

Figure 5: Coastal Demand Shortages



Sasol MRG is currently the only dedicated supplier to the eastern coast and flows from Secunda through the Lilly pipeline to KwaZulu-Natal. As mentioned, this supply will cease from 2027. A possible replacement source, closer to the east coast node, would be LNG imports through Richards Bay. There are currently no gas sources on the southern and western coasts to supply those demand nodes. Possible sources would be potential fields such as Block 2A and Block 11B/12B, and LNG imports from Saldanha Bay and Ngqura as reflected in Figure 6.

Figure 6: Coastal Topology



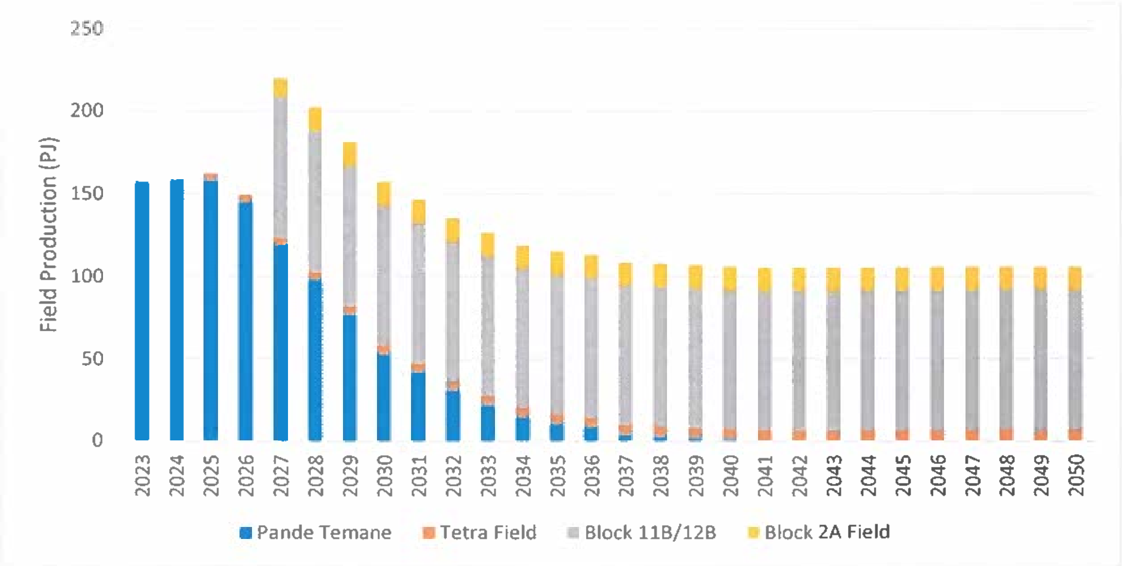
Comparing the inland with the coastal shortages, the inland demand shortage becomes greater with time, as most of the demand projection growth is seen inland, while demand projection at the coastal remains flat for most of the planning horizon.

6.2 Indigenous Field Production Analysis

This section analyses the model outputs after optimisation. The base case/reference case supply output profile, which considers the existing and potential indigenous natural gas fields, is illustrated in Figure 7.

The country's main contributors' fields of natural gas are Pande-Temane gas fields located in Mozambique. The gas feed from this field is expected to decline from 2026 as a major change is observed in the profile. It should be observed that there will still gas flowing from this field to service demand in South Africa up to 2035, although the volumes will be declining from 2026. At the same time, MRG produced from Sasol Gas plant reduces the supply options due to Sasol indications that it will consume this for own use from 2027. Virginia (Tetra) started producing during the second half of 2022 and is expected to ramp up over time, reaching a steady state in 2026/27.

Figure 7: Production Rate of Indigenous Gas Fields



In the base case/reference case, Block 11B/12B is producing to the maximum of PetroSA's capacity at 85 PJ per year. Block 2A reserves supply Atlantis and the remainder is passed through to Mossel Bay to meet the power demand of about 5 PJ at that node. As can be seen, indigenous gas production is not sufficient to meet the total projected demand, hence the need to import LNG to reduce the shortages in short to medium term whilst the government stimulates indigenous exploration activities.

Should any of the projected indigenous supply not materialize, the gap between supply and demand widens, placing even higher reliance on LNG imports.

6.3 Liquified Natural Gas (LNG) Import Volumes and Infrastructure

For LNG imports to meet the growing gas demand, LNG import infrastructure should be developed, considering LNG lead times for the development of such bulk infrastructure projects. To optimally import gas into the country, LNG port terminals are to be located at the ports of Richards Bay, Ngqura and Saldanha Bay in South Africa, and possibly in the western and eastern regional ports.

6.3.1 Optimized LNG Terminals And Imported LNG Volumes

Figure 3 and 5 above illustrate the inland and coastal shortages which can realistically be met by LNG import. These LNG volumes can be obtained through the ports identified (Richards Bay, Ngqura and Saldanha Bay). The Floating Storage Regasification Unit (FSRU) terminals to be used are dedicated to RMI4P FSRUs from 2024 to 2030, thereafter the model selects from various options provided.

From 2030, the results show that the model optimizes the FSRU Buy options in Richards Bay, Ngqura and Saldanha Bay, thus retiring all the RMI4P FSRUs. Commercial viability of Matola LNG remains in question though. The optimised LNG terminals are therefore shown in Table 7.

Table 7: Selected Terminal Technologies

Technology	Sizes (m3)	Year							
		2023	2027	2029	2030	2035	2040	2045	2050
Regional (Onshore or FSRU: Lease)[7]	125 000 - 170 000								
RMI4P (FSRU: Lease) RB, SB, NGQ	125 000								
Technology: Buy – RB	170 000								
Technology: Buy – Ngqura	125 000								
Technology: Buy – SB	125 000								

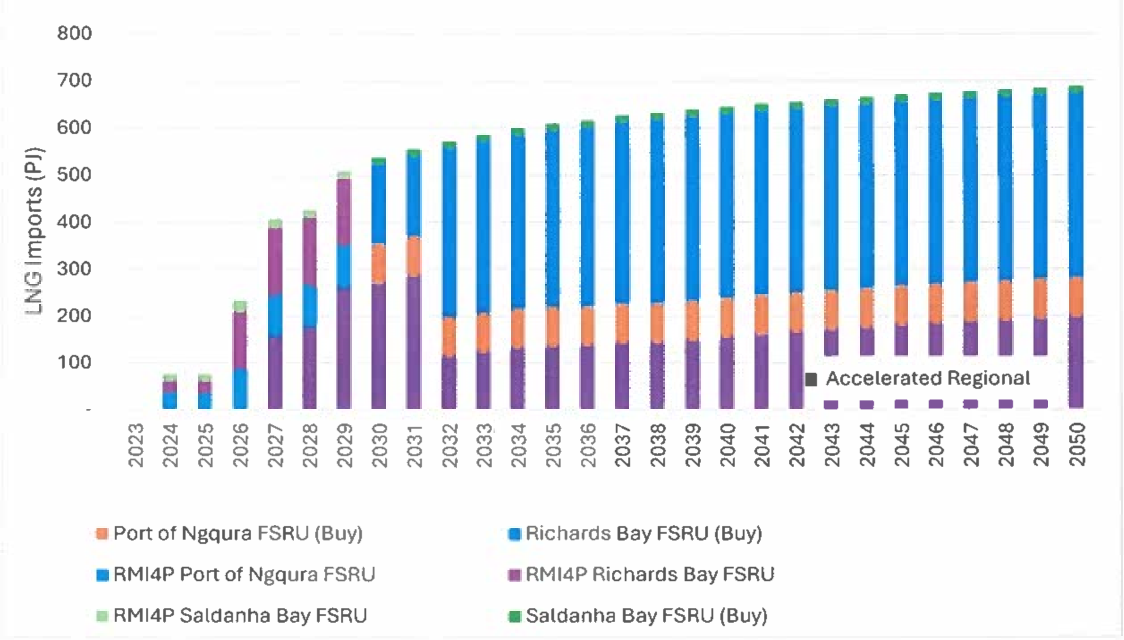
The LNG import volumes in each of these chosen LNG terminals are shown in Diagram 4. Initially, the RMI4P FSRUs in all the terminals are the sources of gas not only for the RMI4P but also for other nodes. The Richards Bay terminal is planned to also supply inland demand, together with increased regional import supply.

[7] Regional options are not restrictive to LNG only. Other fields could offer better supply opportunities.

This import supply will reach 284 PJ/a in 2031 and drop to 112 PJ/a in 2032 when the FSRU in Richards Bay ramps up operation and gradually increases, reaching 196 PJ/a in 2050. The model gradually introduces Richards Bay LNG imports, starting with supply from the RMI4P FSRU from 2024, then utilises a larger FSRU from 2030.

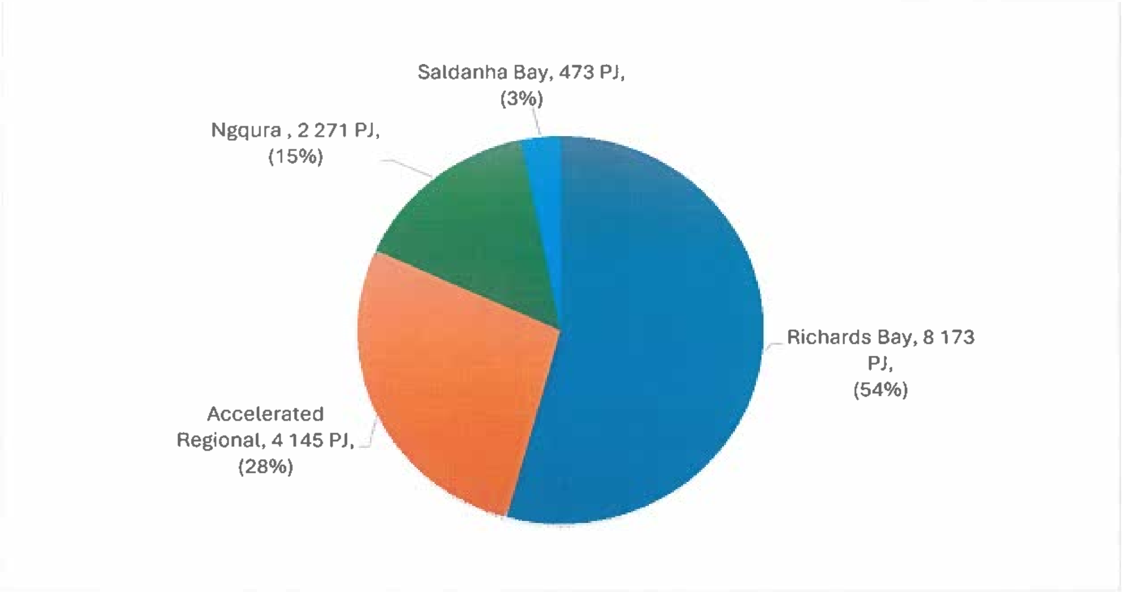
The Richards Bay imports increase from 165 PJ/a in 2030 to reach a peak of 387 PJ/a in 2038 and remain stable until the end of the planning horizon.

Figure 8: Imported LNG Volumes and Associated Technologies



Imports from Ngqura are aimed at meeting the power demand in the area and will supply 88 PJ per year until the end of the planning horizon. LNG imports through Saldanha Bay will supply power demand in Saldanha Bay at 17 PJ per year. Figure 9 shows the total volumes that would be supplied by these LNG terminals for the duration of the planning horizon 2023 to 2050, with the largest volumes expected to come from Richards Bay and the smallest from Saldanha Bay.

Figure 9: Total LNG Volumes (PJ) Imported in Each Port from 2023 to 2050



6.4 Total Gas Supply, Demand and Shortages

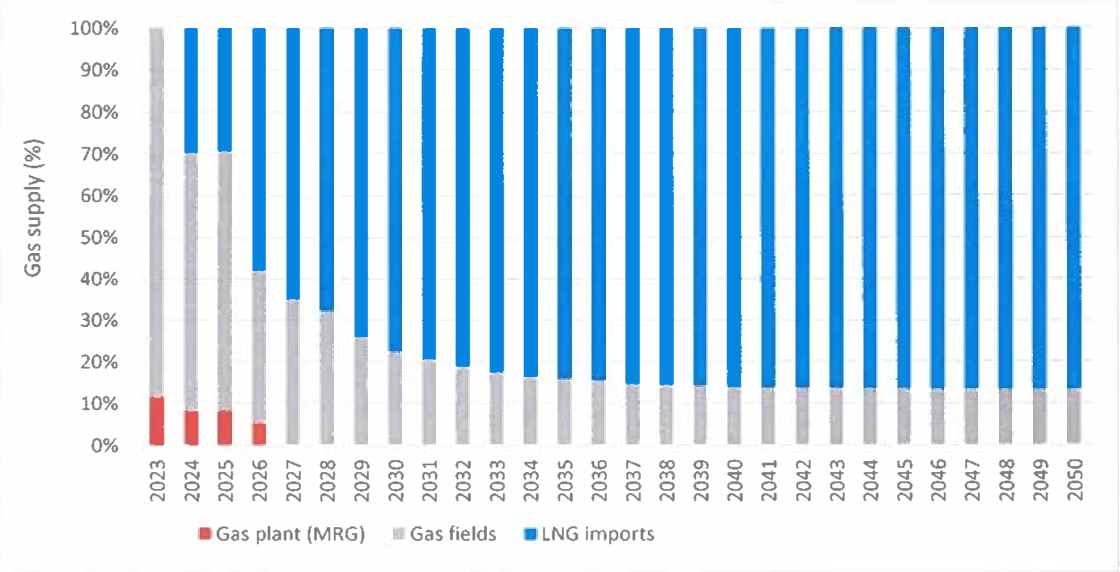
6.4.1 Total Gas Supply

LNG imports are expected to account for about thirty percent (30%) of the total supply when introduced in 2024, growing to about eighty-seven percent (87%) in 2050 with gas plants (MRG) and gas fields accounting for the remainder during the planning horizon.

With no further developments in indigenous fields, the identified gas fields in the base case/reference case, currently supplying about 160 PJ and peaking at just over 200 PJ in 2027, will supply approximately 100 PJ by end of the planning horizon.

This outlook can be changed significantly by acceleration of shale gas field development and the country could transition from being an importer to become a net exporter of natural gas with significant economic benefits.

Figure 10: Total Gas Supply (Without Shale Gas)

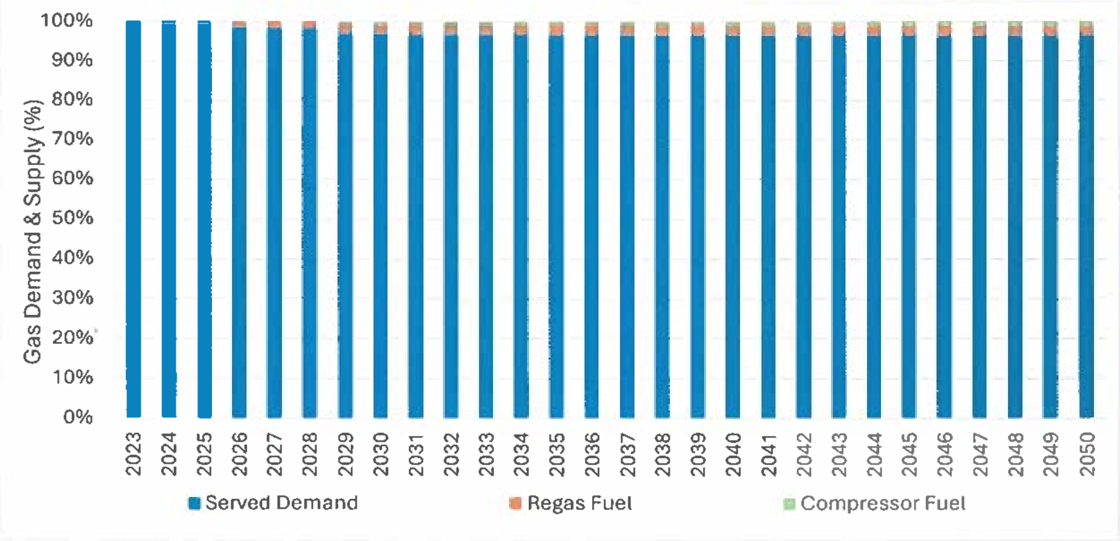


6.4.2 Demand

Figure 11 shows how the gas supplied is consumed. As seen below, most of the natural gas is for served demand. From 2024 to 2028, the total supply was distributed amongst the served demand and the regas fuel while pipelines compressors started consuming portion of the total supply from 2029.

By 2050, regas and compressor fuel contributed two point twenty-five percent (2.25%) and one point fifty-four percent (1.54%) of the total supply respectively. It is assumed that four percent (4%) of the throughput will be used to fuel compressors, while two point sixty-three percent (2.63%) of the LNG will be used by vaporizers to regasify the LNG to natural gas before sending it out by the pipeline.

Figure 11: Gas Balance After Optimization



6.4.3 Shortages

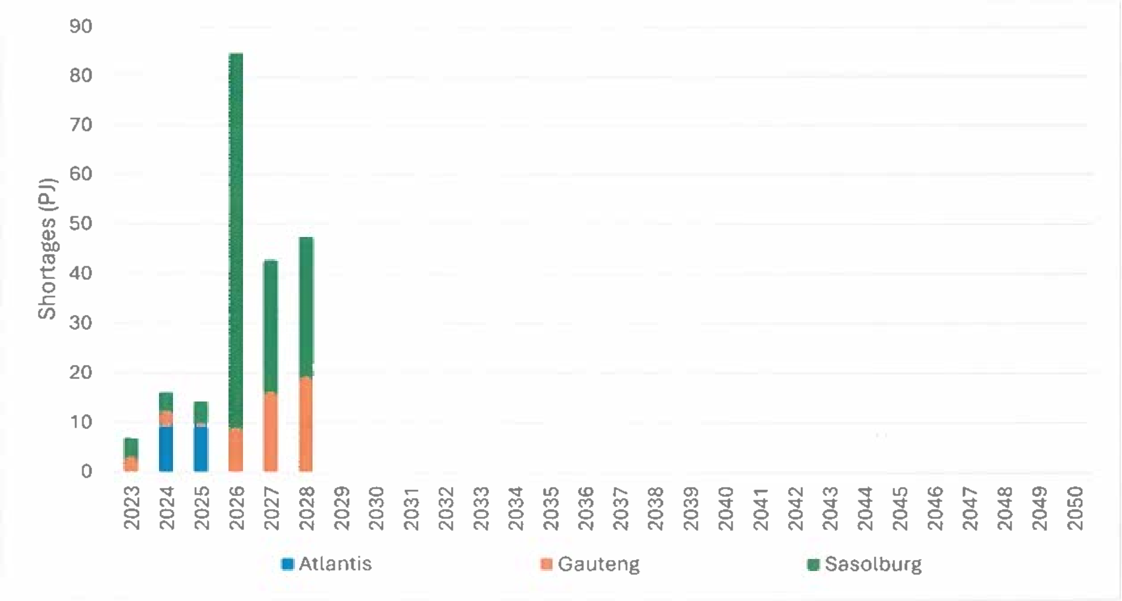
Shortages occur after optimization between 2023 and 2028 as shown in Figure 12. These shortages occur due to the unavailability of potential gas fields as well as LNG imports, or insufficient imports to deal with the demand. To exacerbate the shortages, imports from Pande-Temane starts to decline from 2026 as the projected demand in Sasolburg is expected to increase in the same year, thus the quantum of shortages increases in that year.

Increasing Regional import from 2027 eliminates some of the shortages inland, however with demand expected to grow in Middleburg, the additional gas supplied through ROMPCO is first used in Middleburg, before reaching Gauteng. Thus, creating shortages in Gauteng between 2027 and 2028.

By 2029 all the shortages are eliminated due to expected completion of ROMPCO capacity expansion through assumed loop lines and enabling increased transmission of gas from Mozambique. Inland shortages (Gauteng and Sasolburg) are mainly eliminated by increased imports from Mozambique and LNG imports through Richards Bay in the planning horizon. Shortages at Atlantis are met by supply from the Block 2A field once available.

To mitigate against gas supply shortages between 2026 and 2030, it is quite urgent to engage within the region to establish enablers that could unlock additional regional supply potential. Government to government agreements could be relevant instruments to unlock such regional projects.

Figure 12: Shortages After Optimization



6.5 Supply Per Demand Node

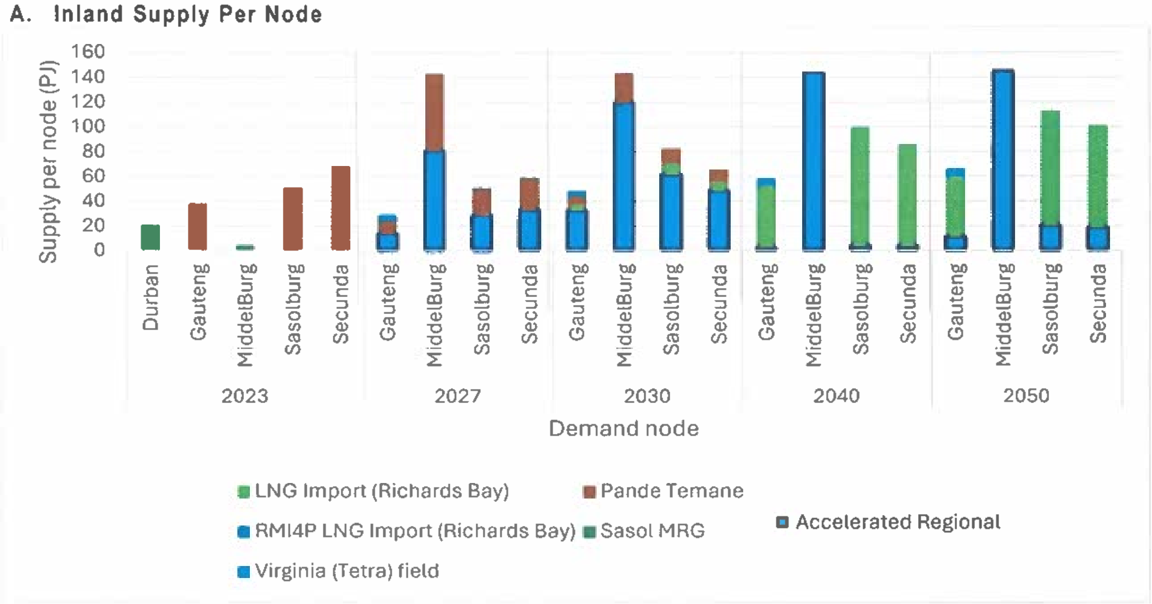
6.5.1 Inland and Coastal Supply

Given the projected demand in each node, as well as the supply options and infrastructure investment options, the gas system in the country is balanced as seen in Figure 13 (A. for Inland and B. for Coastal).

The figures depict optimized supply options in each demand node across the planning horizon. Each node is supplied by different sources based on availability and proximity to the source. In 2023, only the existing demand nodes and supply options are depicted and from 2027 the potential demand nodes are added, along with the potential supply options.

Figure 13: Supply Per Demand Node

A. **Inland Supply Per Node**



The inland demand nodes during 2023 were supplied by the existing gas supply sources from Pande-Temane (Mozambique) to Secunda (South Africa) using the ROMPCO gas transmission pipeline. Subsequently, Gauteng and Sasolburg demand nodes were supplied with gas from Pande and Temane using pipelines linking Secunda-Gauteng and Secunda-Sasolburg respectively. Middelburg was supplied with Sasol MRG through a pipeline between the two (2) nodes (Sasol MRG-Middelburg). A small amount of demand in Gauteng is supplied by the Virginia (Tetra) field using virtual pipeline (road network).

In **2027**, the potential supply from the Region provides supply at all four (4) inland nodes via ROMPCO and the other existing pipelines as Pande and Temane begins to decline and demand increases. However, in the case of Middelburg, a new diverting pipeline from ROMPCO to Middelburg is constructed, transporting gas from both Pande and Temane and other potential fields to meet the increased demand at Middleburg node, following the cease of Sasol MRG supply in 2026 and the decommissioning of the

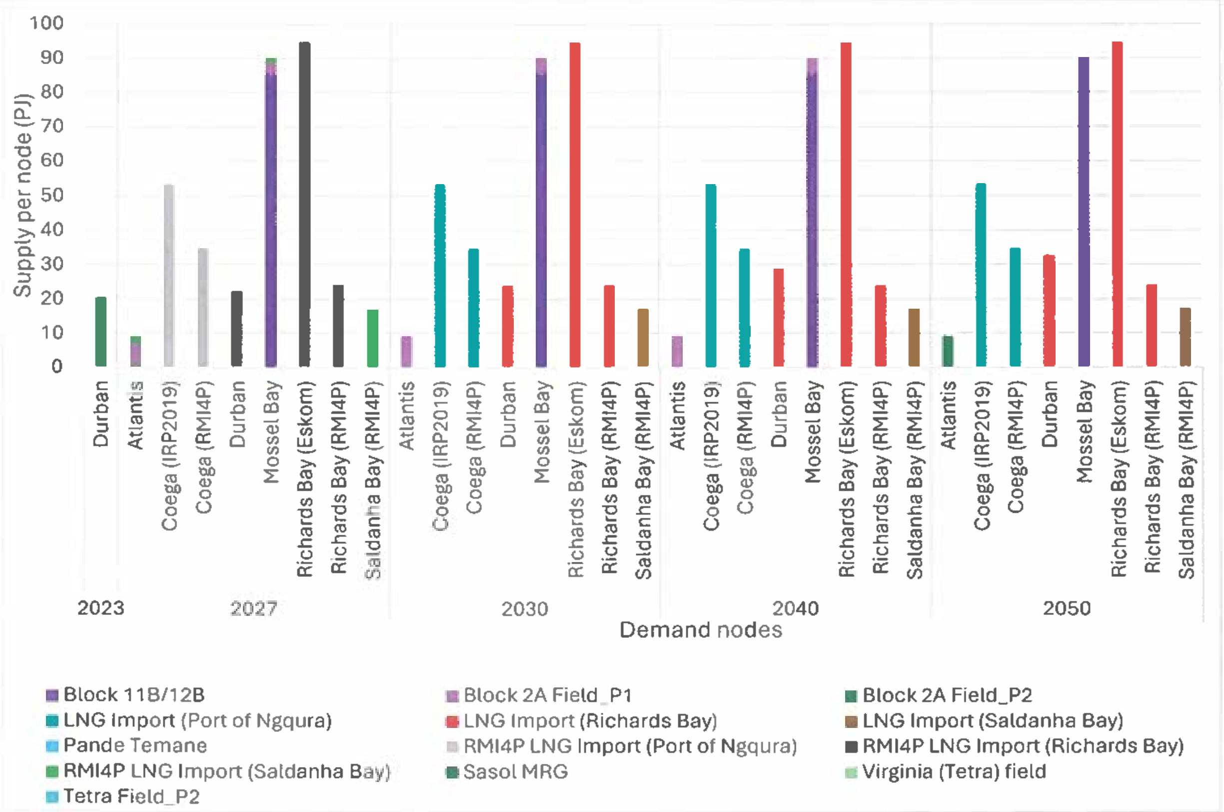
Sasol MRG-Middelburg pipeline. To unlock regional potential supply from 2027 requires government to government agreements.

In **2030**, as the supply from Pande and Temane continues to decline, the regional import supply increases and gas from the Richards Bay LNG terminal is introduced to the inland nodes, transported via the potential pipelines from the Richards Bay LNG terminal (Richards Bay-Empangeni) to Secunda (Empangeni-Secunda).

After **2040**, Pande Temane ceases to produce gas and majority of the inland demand is met by gas from the Richards Bay LNG terminal, while Middelburg is supplied by imports from the Region.

Similar trend continues to 2050, with introduction of P2 field of Virginia (Tetra) to supply demand in Gauteng. This field replaces P1.

B. Coastal Supply Per Node



In 2023, the supply to the demand in Durban is from Sasol MRG through the Lilly Pipeline.

In **2027**, Durban is supplied by RMI4P LNG in Richards Bay through the Lilly pipeline (Empangeni-Durban), following the expected Sasol MRG supply stoppage in 2026. The Atlantis demand node is supplied from Block 2A Field (P1) through Block 2A-Abrahams, Abrahams-Saldanha, Saldanha-Atlantis pipelines (connected in series). This supply is then supplemented by the supply from the RMI4P LNG Import (Saldanha Bay).

The demand in Coega for both IRP2019 and RMI4P is supplied through the import terminals of RMI4P LNG (Port of Ngqura). Mossel bay demand node is mainly supplied by Block 11B/12B field through the Block 9-Mossel Bay pipeline and is supplemented by supply from Block 2A field (P1) through series of pipelines (Block 2A-Abrahams, Abrahams-Saldanha, Saldanha-Atlantis, Atlantis-Mossel Bay).

The Richards Bay demand (Eskom and RMI4P) will be supplied by the RMI4P LNG Imports from Richards Bay through Richards Bay-Empangeni pipeline. The Saldanha Bay (RMI4P) demand node is supplied from the RMI4P LNG Import (Saldanha).

To meet the increasing projected demand, the FSRU Infrastructure for LNG imports for RMI4P purpose is retired in 2030 and a new and bigger infrastructure is installed in different ports to supply both RMI4P and neighboring demand nodes.

In **2030**, the Durban demand node is supplied by LNG Import from Richards Bay through the Richards Bay-Empangeni and Empangeni-Durban pipelines. The demand node from Eskom and RMI4P in Richards Bay are also supplied through the LNG Import in Richards Bay.

The Coega IRP2019 and RMI4P demand nodes are supplied by the LNG import from Port of Ngqura, while the demand nodes from RMI4P in Saldanha will be supplied by LNG Import (Saldanha), with the trend continuing to 2040.

In **2050**, Block 2A Field (P2) will supply the Atlantis demand node through Block 2A-Abrahams, Abrahams-Saldanha Bay, Saldanha Bay-Atlantis pipelines following the depletion of Block 2A field (P1). The supply to the other demand in Mossel Bay will be supplemented by Block 2A Field (P2) through the Atlantis-Mossel Bay pipeline.

Table 8 provides a summary of the required pipeline infrastructure whilst Table 9 provides information on the FSRU required to supply imported gas, as articulated in Section 6.5.1.

Table 8: Pipeline Infrastructure

		Supply Nodes (from)											
		Block 11/12B Field	Block 2A Field	Pande & Temane	Virginia (Tetra) Field	Regional source	RMI4P Port of Ngqura FSRU	RMI4P Richards Bay FSRU	RMI4P Saldanha Bay FSRU	Port of Ngqura FSRU (Buy)	Richards Bay FSRU (Buy)	Saldanha Bay FSRU (Buy)	Sasol MRG
Demand nodes (to)	Atlantis		✓(2027)						✓ (2026)			✓ (2030)	
	Coega (IRP2019)						✓(2026)			✓(2030)			
	Coega (RMI4P)						✓(2024)			✓(2030)			
	Durban							✓(2027)			✓(2030)		✓(current)
	Gauteng			✓(current)	✓(current)	✓(2027)		✓(2027)			✓(2030)		
	Middelburg			✓(2026)		✓(2027)							✓(current)
	Mossel Bay	✓(2027)	✓(2027)						✓(2027)				
	Richards Bay (Eskom)							✓(2026)			✓(2030)		
	Richards Bay (RMI4P)							✓(2024)			✓(2030)		
	Saldanha Bay (RMI4P)								✓(2024)			✓(2030)	
	Sasolburg			✓(current)		✓(2027)		✓(2027)			✓(2030)		
	Secunda			✓(current)		✓(2027)		✓(2027)			✓(2030)		

Table 9: Floating Storage Regasification Units

	Ports (Import)		
	Richards Bay	Ngqura	Saldanha Bay
FSRU	Lease (2024)	Lease (2024)	Lease (2024)
	Buy (2030)	Buy (2030)	Buy (2030)

7. RECOMMENDATIONS

The South African Government should continue in its endeavour to diversify the country's energy sources with the intention of reducing its heavy reliance on unabated coal and realize an effective energy mix while improving the country's security of energy supply and reducing emissions in the long-term. Large-scale indigenous natural gas production could substantially improve in the near future, but currently remains a distant goal. The country should therefore drive massive additional exploration projects, while simultaneously enabling potential developments of other forms of gas available to South Africa.

Strengthening energy and investment policies to create an enabling environment for the widespread use of natural gas in the country should be amongst key government's priorities. Such approach could increase indigenous exploration and production activities and thus opportunities to produce gas for local use and export markets in the medium to long-term.

The importation of natural gas, in the form of piped gas and LNG from neighbouring countries with excess supply, is a realistic option in the short to medium term. The availability of gas for the domestic market would facilitate industrialization and the development of the gas industry, including LNG, gas processing and gas pipeline infrastructure. Such investments will contribute significantly to the country's GDP and create job opportunities locally.

To stimulate domestic market in the short/medium term, South Africa should thus focus on driving initiatives and programmes aimed at promoting the development and importation of LNG as a medium-term solution. Furthermore, to mitigate against supply-demand shortfall anticipated in the period between 2026 and 2030, engagements within the region to establish enablers that could unlock additional regional supply potential must be prioritized. Government to government agreements could be relevant instruments to unlock such regional projects.

Implementation of the Gas Master Plan should maintain a strategic focus of diversifying gas supply options by pursuing both indigenous pipeline and import LNG options to minimise the geopolitical risks and security of supply threats that come with relying significantly on imported gas. The diversification of gas supply will provide the domestic market with efficient choices, competitive prices, and accessibility to gas.

The country should thus strike a balance between domestic/indigenous gas, piped import and LNG import to ensure diversification of supply sources and reduced risks to security of supply. High volatility of LNG prices could pose a risk to the country; therefore, pricing must be carefully monitored, and sufficient regulatory instruments enhanced.

8. CONCLUSION

In conclusion, it is abundantly evident that the South African economy is heavily reliant on the availability of affordable energy carriers. In the case of natural gas, the supply of natural gas poses an immediate challenge to the development of the country's gas industry.

As depicted in the base case modelling results, the gas demand far exceeds the supply, this shortage is expected to worsen in the near future as demand is projected to grow. To satisfy the country's limited and declining natural gas resources, the development of the gas market as an alternative source of energy should therefore be urgently explored.

Policy Position 7 of the Integrated Resource Plan (IRP 2019) advances implementation and pursuing of a greater support for the development of gas infrastructure, to meet the projected gas-to-power programme. Thus, to meet the primary energy requirements of gas-to-power programme, the Gas Master Plan recommendations should be prioritised.

The establishment of the country's gas market will create several opportunities for various economic sectors and opportunities to upskill the existing workforce, transfer international skills and create new work, beyond the power sector. Enabling domestic gas market is a building block that will improve the economic outlook and transition the country towards poverty alleviation and better lives for indigenous citizens.