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DEPARTMENT OF MINERAL RESOURCES AND ENERGY

NO. 4238 **4 January 2024**

PUBLICATION FOR COMMENTS: INTEGRATED RESOURCE PLAN, 2023

I, Samson Gwede Mantashe, Minister of Mineral Resources & Energy, under Section 4(1) of the Electricity Regulations on New Generation Capacity, hereby publish the Integrated Resource Plan, 2023 for public comments.

Interested and affected persons and organisations are invited to submit written comments on or before 23 February 2024. Comments on the Integrated Resource Plan, 2023 must be submitted to the Director-General of the Department of Mineral Resources & Energy.

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

SAMSON GWEDE MANTASHE, MP
Minister of Mineral Resources & Energy
Date: 04/01/2024.

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Glossary of Terms

Term/Abbreviation	Definition
Department of Forestry, Fisheries and the Environment	*Government department mandated to give effect to the right of citizens to an environment that is not harmful to their health or well-being and to have the environment protected for the benefit of present and future generations through reasonable legislative and other measures.*
Department of Mineral Resources and Energy	*Government department mandated to ensure secure and sustainable provision of energy for socio-economic development.*
Energy Availability Factor	*The percentage of the maximum energy a plant can supply to the grid when not on planned or unplanned outage.*
Green Hydrogen gas	*Process of producing hydrogen gas from clean energy courses.*
Integrated Resource Plan	*A generation capacity expansion plan based on a least-cost electricity supply and demand balance in the long term and incorporates government policy.*
Just Energy Transition	*Shift from a high to low carbon-intensive energy system.*
Long-term Operation	*The operation of the nuclear installation beyond an established time-frame set forth by, for example, the licence term, design, standards, licence or regulations, which have been justified by safety assessment, with consideration given to life-limiting processes or features of structures, systems, and components.*
Minimum Emission Standards	*Regulations published under the National Environmental Management: Air Quality Act (NEMAQA) 39 of 2004.*
National Energy Regulator of South Africa	*A regulatory authority mandated to regulate the electricity, piped-gas and petroleum pipelines industries in terms of the Electricity Regulation Act, 2006 (Act No. 4 of 2006), Gas Act, 2001 (Act No. 48 of 2001) and Petroleum Pipelines Act, 2003 (Act No. 60 of 2003).*
National Nuclear Regulator	*The legal entity established in terms of the National Nuclear Regulator Act 47 of 1999.*
National Energy Crisis Committee	*A committee established to coordinate and accelerate government's efforts to reduce loadshedding.*
Net Zero Position	*The balance between the amount of greenhouse gas emissions produced and the amount that is reduced from the atmosphere. The focus is often on reducing as much carbon emissions as possible first and offsetting residual emissions as a last resort.*

Open-cycle Gas Turbine	*A combustion-type turbine using liquified/gas fuel typically for emergency periods.*
Renewable Independent Power Producer Procurement Programme	*A vehicle set up to procure electricity from renewable and non-renewable energy sources from the private sector.*
Risk Mitigation Independent Power Producer Procurement Programme	*A programme designed by the DMRE to fulfil the Minister's directive identified by the IRP 2019 gazette.*
Small-scale Embedded Generation	*Power generation facilities located at residential, commercial or industrial sites, where electricity is generally also consumed and may be exported onto the grid.*
Unserved Energy / Energy Not Served	*A measure of demand that cannot be reliably met due to supply-side shortages.*
Generation Connection Capacity Assessment	*Triggered by the next bid window process and refers to the amount of generation that can be accommodated on the transmission system at a given time and at a given location without adversely affecting grid reliability and without requiring significant infrastructure upgrades.*
South African Grid Code	*The Grid Code is intended to establish the reciprocal obligations of industry participants around the use of the transmission system and operation of the interconnected power system.*

Abbreviations and Acronyms

BESS	Battery Energy Storage System
CCGT	Closed Cycle Gas Turbine
CCUS	Carbon Capture and Utilisation Storage
CO_2	Carbon Dioxide
COD	Commercial Operation Date
CSP	Concentrating Solar Power
DFFE	Department of Forestry, Fisheries and the Environment
DMRE	Department of Mineral Resources and Energy
DSM	Demand Side Management
EAF	Energy Availability Factor
EIA	Environmental Impact Assessment
EC	Eastern Cape Region
ESI	Electricity Supply Industry
FBC	Fluidised Bed Combustion coal technology
FGD	Flue Gas Desulphurisation
GCCA	Generation Capacity Connection Assessment
GDP	Gross Domestic Product
GW	Gigawatt (one thousand megawatts)
H_2	Hydrogen Gas
KNPS	Koeberg Nuclear Power Station
IRP	Integrated Resource Plan
LTO	Long-Term Operation
MES	Minimum Emission Standards

MTSAO	Medium Term System Adequacy Outlook
MW	Megawatt
NEMAQA	National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004)
NERSA	National Energy Regulator of South Africa
NNR	National Nuclear Regulator
PF	Pulverised-fuel coal technology
PV	Photovoltaic
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RMIPPPP	Risk Mitigation Independent Power Producer Procurement Programme
RSA	Republic of South Africa
SAGC	South African Grid Code
SMR	Small Modular Reactor
SSEG	Small-Scale Embedded Generation
Tcf	Trillion cubic feet
TDP	Transmission Development Plan
TWh	Terawatt hour
WC	Western Cape region

1. The IRP in Context

1.1. The Integrated Resource Plan (IRP) is a living plan that is expected to be regularly reviewed as necessitated by changing circumstances.

1.2. The main purpose of the IRP is to ensure security of electricity supply necessary by balancing supply with demand, while considering the environment and total cost of supply.

1.3. South Africa continues to pursue a diversified energy mix that will provide security of supply while ensuring compliance with its emission reduction plan. South Africa's approach to energy security is in line with international trends and developments.

1.3.1. Coal

Coal continues to play a significant role in electricity generation in South Africa. Given abundance of coal resources in the country, a consideration for investments in more efficient and cleaner coal technologies is necessary.
To this extent the Council for GeoScience in partnership with the World Bank is conducting a Carbon Capture Utilisation and Storage (CCUS) study on a site in Leandra in the Govan Mbeki municipality.

Given the significant investments required for the advancement of CCUS technology, South Africa must continuously pursue strategic partnerships with international organisations and countries that have made advancements in the development of cleaner coal technologies.

1.3.2. Nuclear

Nuclear power is an important clean energy source of electricity generation as it can complement other clean energy technologies in reducing power sector emissions while also contributing to electricity security as a dispatchable power source[1].

There is growing global interest in the deployment of small modular reactors (SMRs). Given their smaller footprint, SMRs can be sited on locations not

[1] International Energy Agency (IEA)

suitable for larger nuclear power plants such as inland regions, along the coast and in remote areas. The flexibility of SMRs enables the potential for hybrid energy systems that combine nuclear and alternate energy sources, including renewables. SMRs can be deployed incrementally (pace and scale) to match increasing energy demand.

Koeberg Power Station reaches end of design life in 2024. In order to avoid the demise of the nuclear power in the energy mix, South Africa has made a decision regarding its design life extension and the expansion of the nuclear power programme into the future. Eskom has successfully completed the replacement of the steam generator for unit 1 at Koeberg Nuclear Power Station. A similar activity will be undertaken for unit 2 which will ensure Koeberg operating licence beyond its original design life of 40 years.

1.3.3. Gas

Gas to power technologies in the form of CCGT, CCGE or ICE provide the flexibility required to complement renewable energy.

While in the short term the opportunity is to pursue gas import options, local and regional gas resources will allow for scaling up within manageable risk levels.

There is enormous potential and opportunity in this respect of the Brulpadda gas resource discovery in the Outeniqua Basin of South Africa, gas resource discovery in the Free State and Mpumalanga provinces, natural gas from Mozambique and Namibia, indigenous gas like coal-bed methane and shale gas.

Co-operation with neighbouring countries is being pursued and partnerships are being developed for joint exploitation and beneficiation of natural gas within the SADC region.

Exploration to assess the magnitude of local recoverable shale, inland and coastal gas are being pursued and must be accelerated.

Availability of gas provides an opportunity to convert to CCGT and run open-cycle gas turbine plants at Ankerlig (Saldanha Bay), Gourikwa (Mossel Bay), Avon (Outside Durban) and Dedisa (Coega IDZ) on gas instead of diesel.

1.3.4. Renewables

Solar PV, wind and Concentrated Solar Power (CSP) with storage present an opportunity to diversify the electricity mix, to produce distributed generation and to provide off-grid electricity. Renewable technologies also present huge potential for the creation of new industries across the value chain.

Looking ahead the global renewable energy market is forecasted to grow significantly as decarbonisation efforts continue and new sources of demand, such as green hydrogen and New Energy Vehicles (NEVs), arise.

Locally, the rollout of renewable energy is set to increase rapidly through public and private procurement programmes as the country aims to achieve energy security while decarbonising the electricity supply. Small Scale Embedded Generation (SSEG) installations are also expected to rise significantly as a result of loadshedding and high electricity prices.

1.3.5. Hydro

This is one of the oldest and largest sources of renewable energy, which uses the natural flow of moving water to generate electricity.

South Africa’s rivers carry potential for run-off river hydro projects. These have been proven feasible with projects in operation by farming communities.

Regarding import hydro, South Africa is currently importing hydropower from Mozambique (Cahora-Basa) with potential for more import hydro from Mpanda Nkuwa which is a hydropower project under development. South Africa has also entered into a Treaty for the development of the Grand Inga Project in the Democratic Republic of Congo (DRC), with some of the power intended for transmission to South Africa across DRC, Zambia, Zimbabwe and Botswana. In addition to this generation option providing clean energy, the regional development drivers are compelling, especially given that currently there is very little energy trade between these countries, due to the lack of infrastructure. The potential for intra-SADC trade is huge as it could open up economic trade.

Naturally, concerns have to be addressed about the risks associated with a project of this nature. South Africa does not intend to import power from one source beyond its reserve margin, as a mechanism to de-risk the dependency on this generation option.

1.3.6. Storage

There is a complementary relationship between Smart Grid systems, energy storage, and non-dispatchable renewable energy technologies based on wind and solar PV.

The traditional power delivery model is being disrupted by technological developments related to energy storage, and more renewable energy can be harnessed despite the reality that the timing of its production might be low during peak demand periods.

Storage technologies including battery systems, compressed air energy storage, flywheel energy storage, hydrogen fuel cells etc. are developments that can address this issue, especially in the South African context where over 6 000 MW of renewable energy has been introduced, yet the power system does not have the requisite storage capacity or flexibility.

1.3.7. Hydrogen

The International Energy Agency's (IEA) 'Net Zero Emission by 2050 Roadmap' [4] identifies green hydrogen (H2) as one of the clean energy sources in the transition to net-zero.

South Africa has several advantages in the pursuit of the hydrogen economy. These advantages include amongst others; expertise in the Fischer-Tropsch process, critical minerals necessary for hydrogen economy, and renewable energy resources.

In October 2021, South Africa approved the Hydrogen Society Roadmap which sets national ambitions and sectors prioritisation on the deployment of the hydrogen economy in South Africa. The country has also approved the Green Hydrogen Commercialisation Strategy (GHCS) which seeks to operationalise the Hydrogen Society Roadmap.

1.4. There has been several developments in the electricity industry in South Africa since the promulgation of IRP 2019 and these in the main include:

1.4.1. The establishment of the Presidential Climate Commission (PCC) which is a multi-stakeholder body established by the President of the Republic of South Africa to advise on the country's climate change response and pathways to a low-carbon climate-resilient economy and society.

One of its main outputs, was the development of the Just Transition Framework. In addition, the Inter-Ministerial Committee (IMC) for Just Energy Transition developed the Just Energy Transition Investment Plan (JET IP) and the subsequent Implementation Roadmap for the period 2023-2027 and which sets out the scale of need and the investments required to achieve the decarbonisation commitments in line with South Africa's Nationally Determined Contribution (NDC).

1.4.2. The Energy Action Plan designed to reduce load-shedding and achieve energy security as announced by President on July 25, 2022. The plan implemented under the supervision of the National Energy Crisis Committee (NECOM) consist of five crucial actions including; improving the availability of existing power generation plants, enabling and accelerating private investment in power generation capacity, accelerating procurement of new capacity from renewables, gas and battery storage, unleashing businesses and households to invest in rooftop solar, and fundamental transformation of the electricity sector to achieve long-term energy security.

1.4.3. The removal of licensing requirements for the development of power generation by consumers (embedded generation) meant to enable and attract more investment necessary to address loadshedding.

This intervention has to date resulted in the registration of projects with a potential generation capacity of over 6 000 MW.

1.4.4. The intervention by National Treasury to address the Eskom debt which impacts on the utility’s ability to sustain operations and invest in additional infrastructure. Addressing Eskom debt effectively will enable much-needed investment in critical transmission and other infrastructure, and proper maintenance of plant and equipment.

1.4.5. Procurement of approximately 6 000 MW of additional generation capacity under the technology agnostic Risk Mitigation Independent Power Producer Procurement Programme (RMIPPPP), Bid Windows 5 and 6 of Renewable Energy and Bid Window 1 of Battery Storage.

1.5. In addition to the developments listed above, several key assumptions have changed since the promulgation of IRP 2019. Key assumptions that changed include the electricity demand projection, Eskom’s existing plant performance, as well as new technology costs. These changes necessitated the review and update of the IRP which has resulted in this draft IRP 2023.

2. IRP Review Methodology

2.1. The IRP Review process was undertaken using the Plexos modelling tool. The tool has a production simulation and capacity expansion capabilities. The production simulation module can produce deterministic economic dispatch or be setup to incorporate stochasticity of parameters that consider variability. Such parameters include electricity demand forecast, unplanned outages, and production profiles of renewable generation resources such as wind and solar PV.

2.2. The capacity expansion module incorporates least-cost principles based on linear optimisation. This balances supply and demand in the medium to long-term by considering cost and performance characteristics of generation options while making provision for specified reliability metrics. The objective is to minimise total power system cost and enable a decision to either operate existing generation resources harder or invest in new resources. This investment decision will be driven by a choice of resources that are cheaper and are able to meet the required power system characteristics, while reducing unserved energy. The decisions are subject to constraints such as user-defined reliability criteria, environmental considerations, water consumption, etc.

2.3. This review considered two-time horizons, the first being the period up to 2030 which is mainly focusing on addressing prevailing generation capacity constraints and what the system requires to close the electricity supply shortage gap.

2.4. The second horizon is covering the period from 2031 to 2050 mainly focusing on the country's long term electricity pathways to guide long term policy choices.

2.5. For Horizon One, five scenarios were developed and assessed based on the state of readiness of projects in the pipeline. The scenarios considered are as follows, first the Risk Mitigation Independent Power Producer Procurement Programme (RMIPPPP, REIPPPP 5 and business projects currently under construction. Second, all project initiatives with a commercial operation date (COD) and a specified location. Third, all project initiatives including those with no grid capacity reservation, COD and specified location.

2.6. Additionally, two scenarios, one comprising the reference case and current gas programme, and another based on improved plant performance according to the generation recovery plan have been modelled.

2.7. The studies for the Horizon entailed:

- An analysis of supply and demand in the period up to 2030, considering the latest developments in the ESI.
- Quantification of generation capacity and energy shortfall.
- Identification and ranking of supply-side initiatives that are currently under consideration in the form of government-led bid window processes and private sector programmes.
- Assessment of the extent to which the proposed initiatives address the shortfall.
- Identification of risks that may significantly impact the power system negatively.
- Proposing of interventions required to improve security of supply of the country's power system.

2.8. For Horizon Two, six energy pathways were considered taking into account the need to ensure energy security and reduction of GHG emissions in line with South Africa's commitments. The pathways are aimed at informing policy decisions about secure and sustainable optimal energy mix for South Africa for the period post 2030. The reference pathway established a benchmark against other pathways and was based on the least cost, considering the need to reduce emissions.

2.9. The studies for the Horizon comprised:

- Identification of existing and anticipated ESI challenges that would impact security of supply.
- Analysing a core set of energy pathways in the medium to long term with the aim of ensuring an adequate, stable, and sustainable power system.

3. Factors Considered in the IRP Review

3.1 Eskom Plant Performance

In the 2019 IRP, Eskom's plant energy availability factor (EAF) was assumed to be averaging 75% while the actual EAF at the time was averaging below 70 percent. Performance for the 2023 financial year has plummeted to 54.72 percent, this is the plant performance level that was assumed in this review which is a conservative approach. In this regard, pillar one of the Energy Action Plan has prioritised the improvement of plant performance and has reported a slight improvement. Under this pillar an independent technical review of Eskom's power stations is underway to diagnose challenges and provide recommendations on actions to be taken. Given that the Eskom fleet still dominates the country's installed electricity capacity at about 80%, the downward spiral of the EAF as reflected in Figure 1 continues to pose a serious threat to security of supply.

This has resulted in high levels of loadshedding for prolonged periods of time leaving the economy exposed to stagnation vulnerabilities.

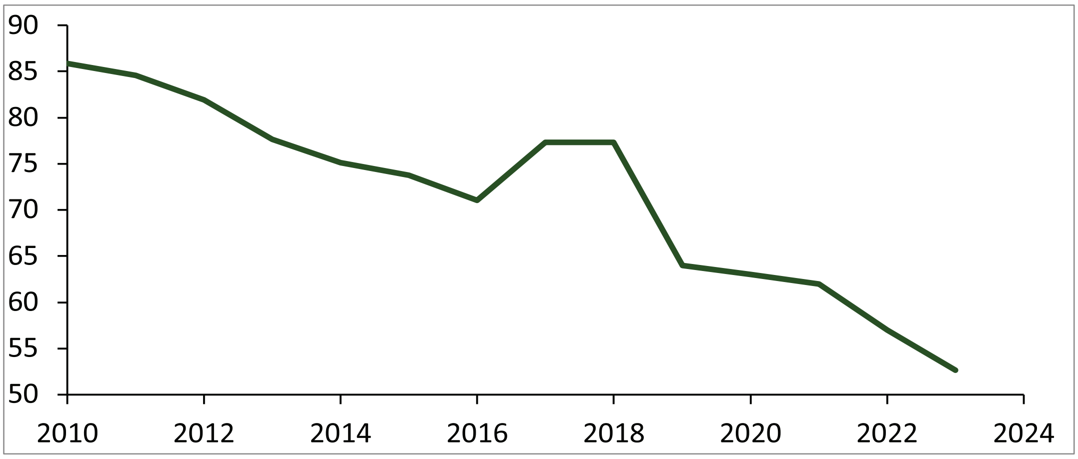

Figure 1: Actual EAF trend from 2010

3.2 Eskom Plants Shutdown Plan

Since the promulgation of the 2019 IRP, the Eskom shutdown has been reviewed and revised as part of the Eskom 2035 Strategy. This resulted in several power stations, earmarked for shutdown before 2030, being operated longer than anticipated. This revision has assisted in reducing the power shortage thus far, though insufficient.

For example, this strategy had dictated that Tutuka power station should be shut down earlier than its 50-year life. This would have meant the shutdown of all six units of Tutuka being shut down by the end of September 2030, 10 years earlier than its design life creating a shortage of 3 500 MW that the station currently generates.

3.3 Eskom New Build Challenges

Commercial operation of Eskom's New Build Programme started with Medupi 6 in August 2015. Since then, other units were also synchronised to the grid however these units are not performing at expected levels due to various factors including design and construction defects. Similarly, there are challenges at Kusile Power Station that impact power output from commissioned units. The focus on repairing major plant defects is ongoing and, based on last year's performance the trend is moving in the right direction.

Kusile Units 5 and 6 are still to be commissioned with the latest forecasts indicating completion in April 2024 and February 2025.

3.4 Koeberg Long-Term Operation Plan

The IRP 2019 recognised the need to retain nuclear power in South Africa's energy mix and acknowledged the role that Koeberg Nuclear Power Station (KNPS) plays in this regard. As the site licence is due to expire in 2024, IRP 2019 supported efforts by Eskom to acquire a licence for long-term operation (LTO) for an additional 20 years. Following the promulgation of IRP 2019, the safety case was submitted by Eskom in 2022, following a peer-review by the International Atomic Energy Agency. The National Nuclear Regulator (NNR) is currently reviewing this safety case in support of the life extension policy decision made in 2019.

3.5 Compliance with Minimum Emission Standards

Air quality regulations under the National Environmental Management Act: Air Quality (Act No. 39 of 2004) provide that coal power plants under Eskom's fleet, amongst others, must meet the minimum emission standard (MES) by a certain time, or they would be non-compliant and cannot be legally operated.

If implemented, the decision will result in the loss of baseload generation capacity in the short to medium term of approximately:

- 16 000 MW immediately and
- Up to 30 000 MW after March 2025, when current postponements lapse.

A balance will have to be found between energy security, the adverse health impacts of poor air quality and the economic cost associated with these plants shutting down.

3.6 Timing and Rollout of New Capacity

To date and following the promulgation of the IRP 2019, over 6 000 MW of new generation capacity has been procured through various procurement programmes. Procured projects are at various stages of implementation with some of the projects delayed or not able to reach legal and financial close.

3.7 Development of the Transmission Grid

According to the Eskom Transmission Development Plan2 (TDP) 2022–2032, the transmission networks of the Eastern, Northern and Western Cape regions have significant capacity constraints [5]. This plan indicates that historical investments in transmission lines over nine years between 2013 and 2022 resulted in just over 4 000 km constructed while more than 14 000 km of new lines are required by 2032. This, therefore, means the country requires accelerating investments in transmission infrastructure by developing new corridors and substations and strengthening existing substations. Eskom is taking steps to fast-track accelerated transformer projects to unlock grid capacity.

[2] https://www.eskom.co.za/wp-content/uploads/2023/01/Transmission_Development_Plan_2023__E280 932032_Rev1.pdf

4. Input Assumption Parameters

Data that informed assumptions used in the IRP Review were collected from a range of stakeholders and sources such as, IPP Office, Eskom, private sector, NECOM, EPRI 2021 and Lazard April 2023 reports.

4.1 Electricity Demand Projection

The country's electricity demand forecast developed by the ERSG of UCT indicates that the demand is currently 19% lower than that projected in IRP 2019 as reflected in Figure 2. The change in demand has been impacted by several local and global factors such as the loadshedding, Covid-19 pandemic and the conflict in Eastern Europe. The IRP 2023 forecast assumes a slower recovery due the prevailing economic climate in the short to medium term. From the mid-2030s, the forecast considers the National Treasury reforms earmarked for aggressive economic growth.

The electricity demand needed for the production of green hydrogen has not been included in the electricity demand forecast on the assumption that entities that will pursue production of this fuel will make own and additional provision for renewable energy.

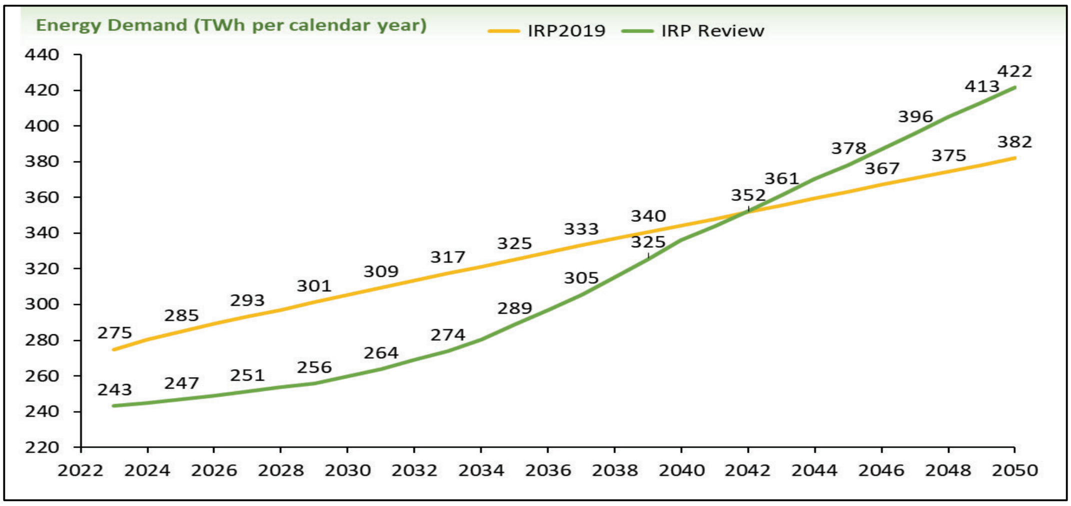

Figure 2: Energy Demand (TWh per calendar year)

4.2 Eskom Plant EAF

The Eskom Generation input into the IRP Review process included high and low EAF scenarios. In May 2023, the high EAF scenario was revised in the Generation Recovery Plan, reflecting the impact of, among others, the collapse of the FGD stack at Kusile Power Station which resulted in three units being offline for extended period. The Generation Recovery Plan assumes recovery to a higher EAF in 2025, as shown in Figure 3. The low EAF scenario assumes continuation of the current declining EAF trend.

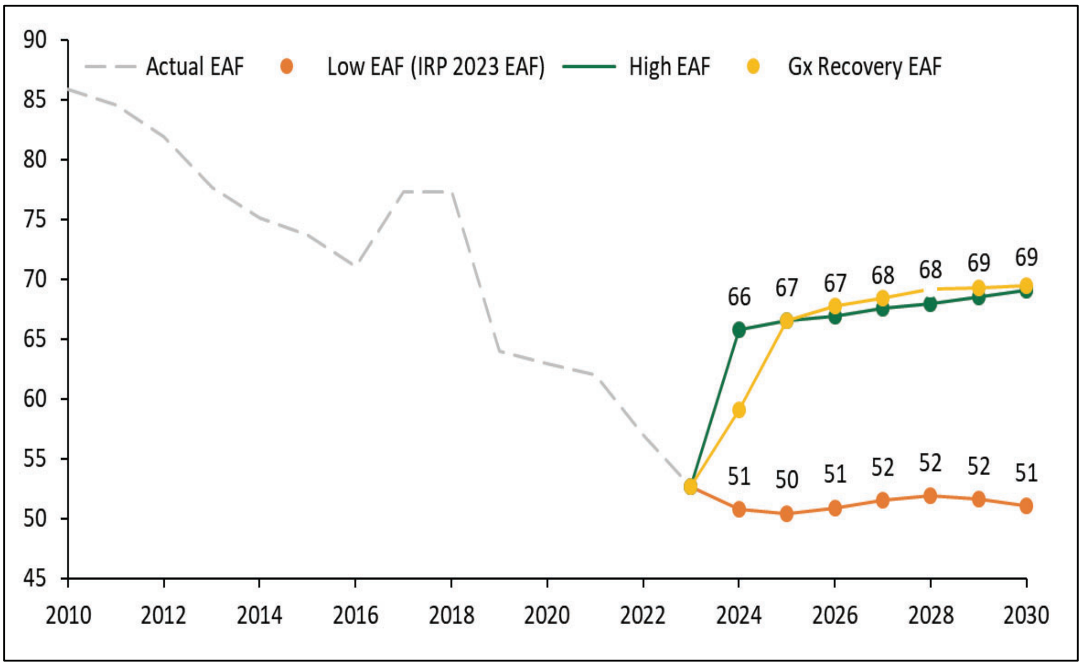

Figure 3: Overview of existing fleet EAF assumptions (%)

4.3 Eskom Shutdown Plan

In so far as the life of coal fired power stations is concerned, the 2023 revised Eskom shutdown plan was considered as an input in the review process and is referred to as the Reference and is shown in Table 1. The dates reflected in the shutdown plan are based on a 50-year life of plant with some power stations shutting down earlier than their design life.

Table 1: Eskom coal fired station shutdown plan

	Arnot	Camden	Duvha	Grootvlei	Hendrina	Kendal	Komati	Kriel	Kusile	Lethabo	Majuba	Matimba	Matla	Medupi	Tutuka
U1	31-Mar-27	30-Aug-24	17-Aug-31	16-Aug-26	01-Apr-18	30-Sep-39	01-Apr-18	05-May-26	29-Aug-68	21-Dec-36	31-Mar-46	03-Dec-38	22-Aug-30	31-Jul-71	15-Mar-30
U2	31-Aug-26	30-Apr-25	30-Sep-31	21-Mar-26	10-Feb-25	19-Jun-41	01-Sep-18	13-May-27	30-Oct-70	10-Jul-37	31-Mar-47	03-Dec-38	29-Jun-31	30-May-69	10-Jan-30
U3	31-Jul-26	30-Nov-24	01-Dec-17	04-Sep-27	01-Jun-17	15-Dec-42	01-Sep-18	27-Jan-28	30-Aug-71	26-Mar-37	31-Mar-48	28-Sep-39	11-Dec-31	30-Oct-68	28-Jul-30
U4	31-Mar-27	31-Jan-23	30-Jun-33	01-Apr-18	31-Mar-25	30-Nov-42	01-Jun-20	21-Aug-29	30-Jun-72	02-Dec-38	31-Mar-49	29-Sep-40	15-Oct-32	30-Nov-67	22-Apr-30
U5	24-Nov-29	30-Nov-25	30-Mar-33	01-Apr-18	31-Dec-25	23-Dec-43	01-Jun-19	12-Mar-29	31-Dec-72	30-Jun-40	31-Mar-50	30-Sep-41	23-Aug-33	30-Apr-67	25-Sep-30
U6	31-Mar-29	31-Jul-23	21-Feb-34	01-Apr-18	13-Sep-25	09-Dec-44	01-Apr-18	16-Nov-30	30-Jun-73	27-Dec-41	31-Mar-51	30-Sep-42	20-Jul-34	31-Aug-65	05-Jun-30
U7		31-Jan-24			19-Mar-24		01-Sep-19								
U8		31-Jul-25			01-Jun-19		01-Apr-18								
U9					01-Oct-19		31-Oct-22								
U10					21-Mar-23										

The analysis of shutdown plans used in IRP 2019 and this review is reflected in Figure 4, and reveals the following:

- Units running longer than their original shutdown dates specified in IRP 2019, indicate a positive net impact capacity in the earlier years,
- Tutuka power station shutdown in 2030 indicates a loss of 3 500 MW of generation capacity.

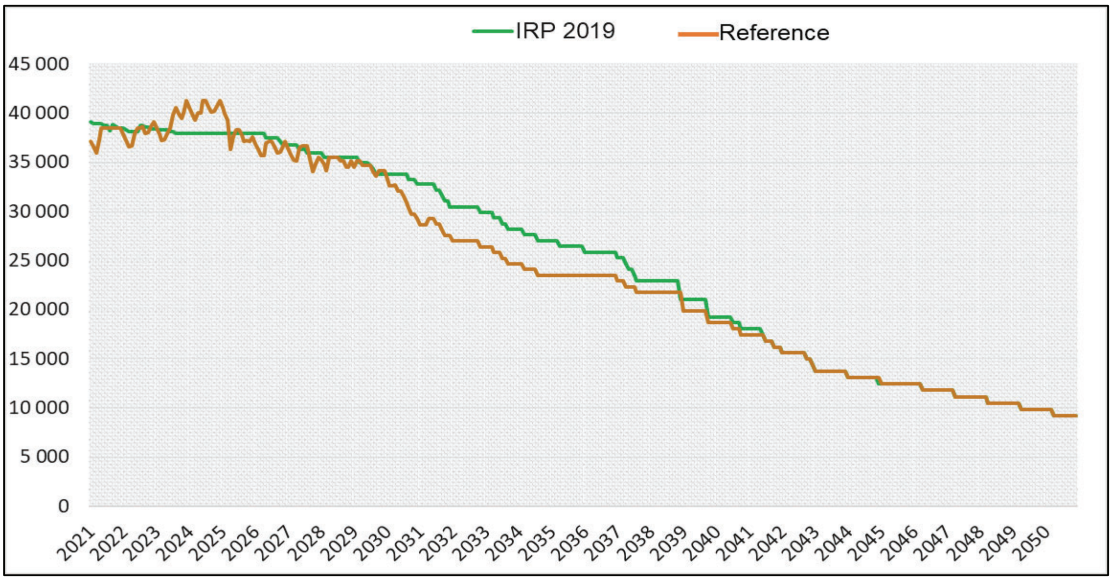

Figure 4: Overview of shutdown impact on existing coal-fired fleet installed capacity

4.4 Transmission Availability

The Generation Capacity Connection Assessment (GCCA) 20243 [6] shows potential capacity available on the transmission network to facilitate connection of generation projects per province as depicted in Figure 5. The GCCA considers all projects under construction including procured projects up to Bid Window 6 but are under construction or have reached financial close. Eskom has also developed Transmission Development Plan (TDP) 2023 – 2032 which shows the expansion and strengthening of the Transmission infrastructure over time.

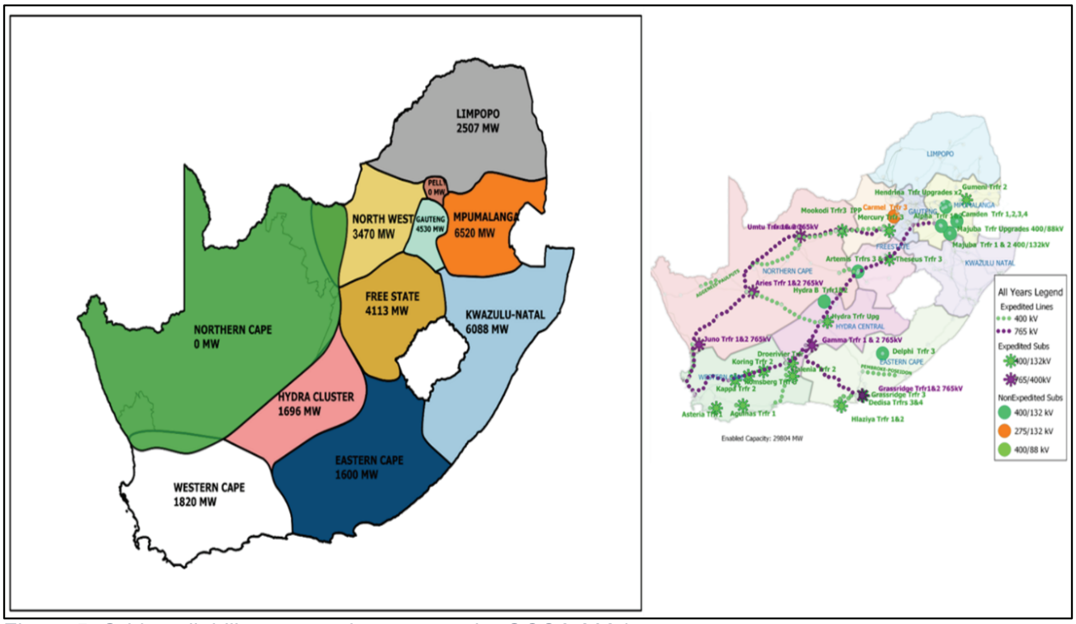

Figure 5: Grid availability per province as per the GCCA 2024

GCCA and the TDP are used in this review to determine additional generation capacity that can be connected to the grid during the study period. See Annexure B for additional grid capacity determination.

4.5 Power Generation Initiatives by the Private Sector

The data on power generation projects by business community indicate a pipeline of projects with a total generation capacity of 10 400 MW by 2030 as shown in Figure 6.

[3] https://www.eskom.co.za/wp-content/uploads/2022/04/Generation-Connection-Capacity-Assessment-GCCA-2024-rev15-Final.pdf

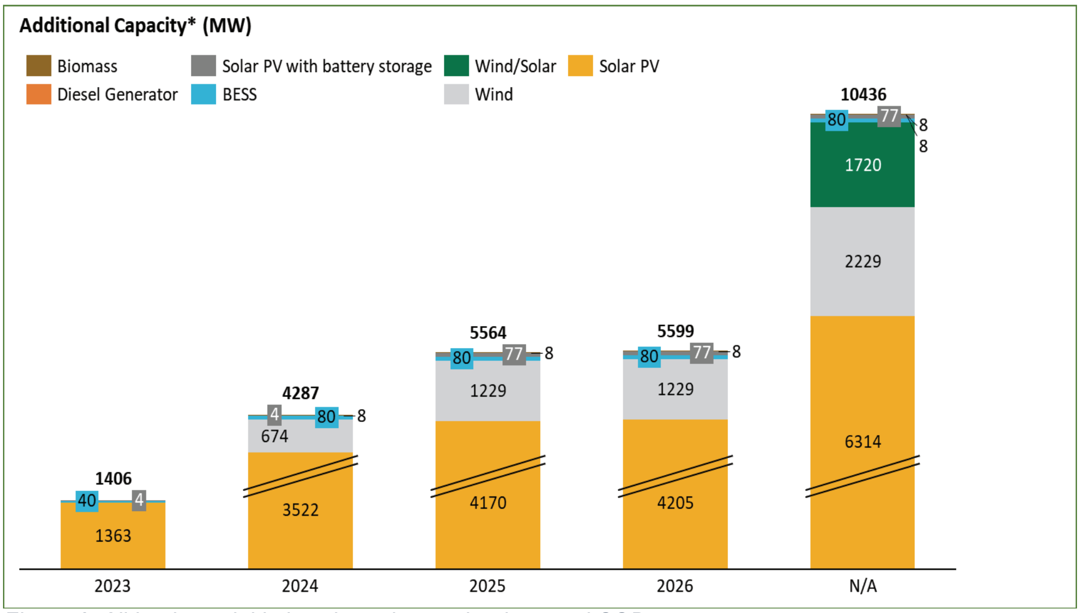

Figure 6: All business initiatives based on technology and COD

Business in Figure 6 above excludes initiatives that do not have a specified location and commercial operation date (COD) as they are deemed to have a low likelihood of materialising. Figure 7 below indicates a scenario with potential where these low likelihood projects are excluded from the projections.

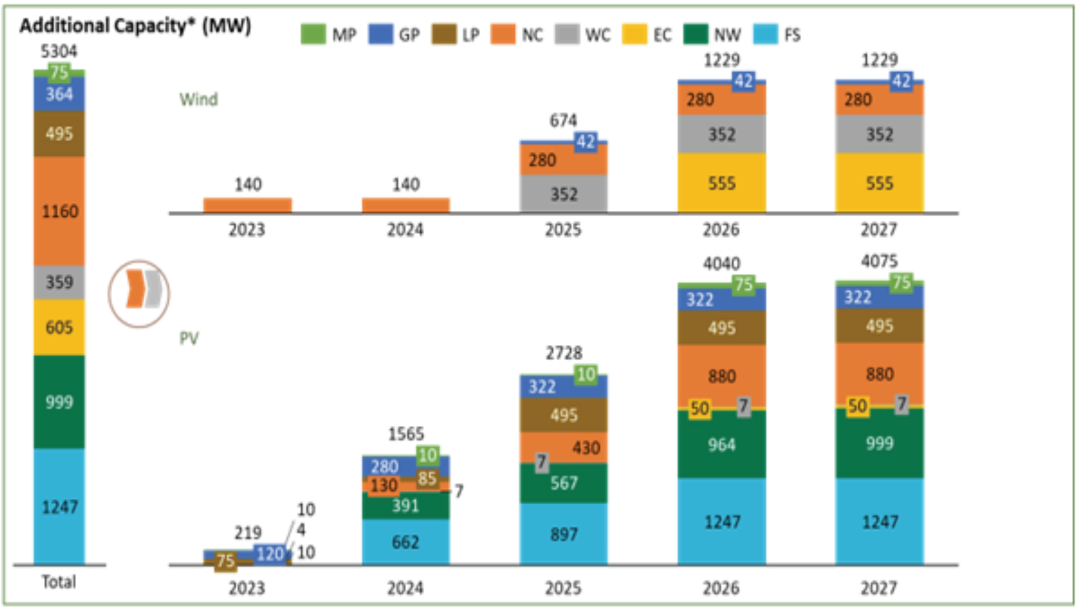

Figure 7: Business Initiatives with location and COD

Figure 8 indicates projects that are under construction and those that have reached financial close.

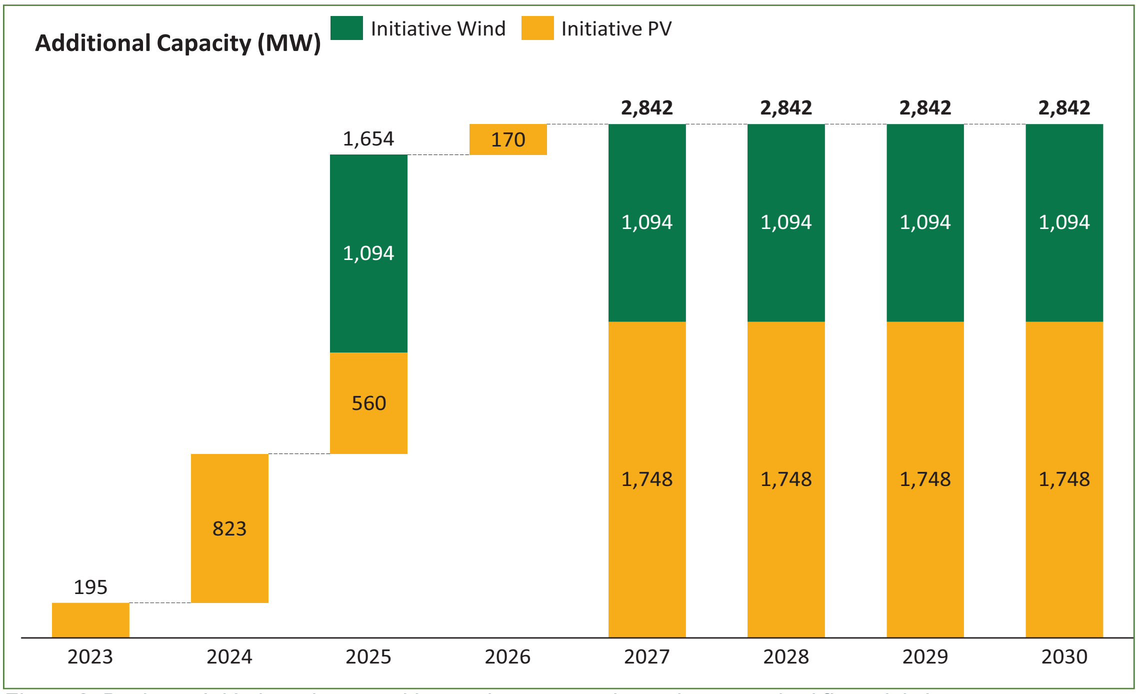

Figure 8: Business Initiatives that are either under construction or have reached financial close.

5. Analysis of Horizon One (Period 2023 to 2030)

The modelling of Horizon One tested four scenarios based on a low EAF and one scenario based on high EAF (Generation Recovery Plan shown in Figure 3), to establish the extent of the supply and demand deficit. The five scenarios were aimed at assessing the impact of supply-side options currently in development by both government and private sector to improve security of supply.

In developing these scenarios, projects in the pipeline were identified and ranked according to their state of readiness. The five scenarios developed are detailed in Figure 9 below.

		EAF	Initiatives 2030 (MW)	New Gas (MW)	Comments
1	Firm Initiatives	49% – 51%	Business 2 842 RMIPPPP 150 REIPPPP 5 Wind 784	0	• Priority Projects as ranked by business and have grid capacity reserved as at June 2023 • Government projects in the RMIPPP + REIPPP programme under construction
2	Reference	49% – 51%	Business 5 304 RMIPPPP 626 REIPPPP 5 PV 975 REIPPPP 5 Wind 1 608 REIPPPP 6 PV 1 140 BESS BW 1-3 + Eskom 2 080	0	• Business initiatives with COD and location • Government projects in the pipeline
3	Firm Initiatives & All Initiatives	49% – 51%	Business 10 436 RMIPPPP 626 REIPPPP 5 PV 975 REIPPPP 5 Wind 1 608 REIPPPP 6 PV 1 140 REIPPPP 7 PV 2 000 REIPPPP 7 Wind 3 000	0	• All initiatives including those with no grid capacity reservation, COD and/or location • Includes REIPPPP 7 due for RFP
4	Firm Initiatives & Gas	49% – 51%	Same as 'Constrained New Build Development' Case	6 220	• Gas includes DMRE Gas, Eskom Richards Bay Gas and RMIPPPP dispatchable Gas
5	Firm Initiatives & Recovery	66% - 69%	Same as 'Constrained New Build Development' Case	0	• Eskom's EAF improvement as per its Generation Recovery plan

Figure 9: Horizon One – Scenarios studied for the period up to 2030

5.1 Results from Analysis of Horizon One

The results of the adequacy of the scenarios from Horizon One in addressing the electricity supply deficit (unserved energy) are summarised in Figure 10 below and explained below.

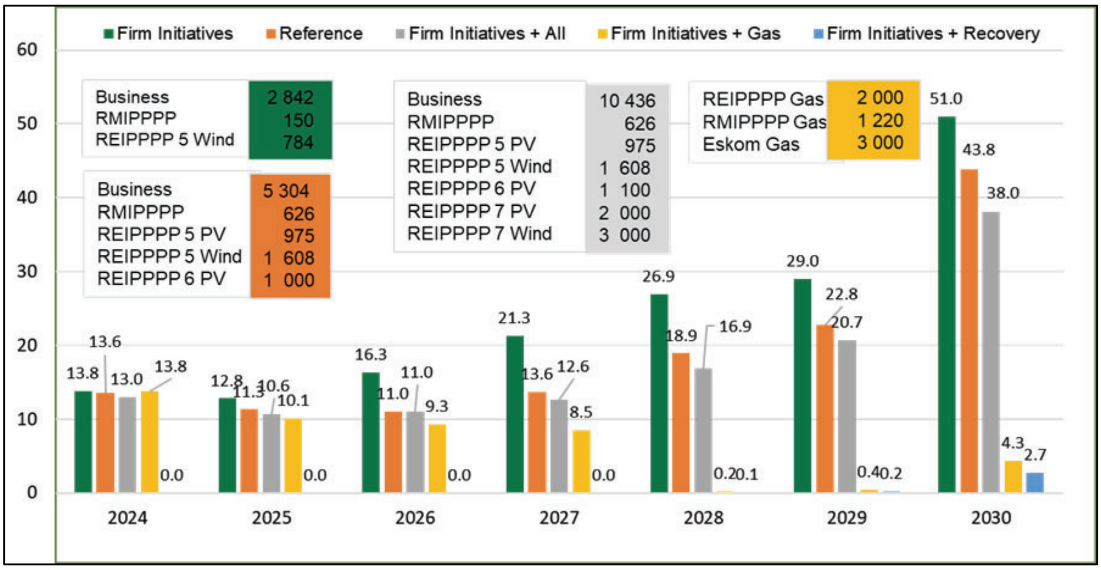

Figure 10: Horizon One Results for all the scenarios modelled

- FIRM INITIATIVES (SCENARIO ONE)

  This scenario considers supply side initiatives under construction by the public and private sector as well as initiatives ranked as priority by the private sector.

  Results of this scenario demonstrated a very high level of unserved energy which imply that the power system is constrained for the duration of the study period. Unserved energy levels could reach a high of more than 50 000 MWh in 2030 as shown in Figure 10 above, equivalent to twice the annual energy produced by a 3 700 MW power station at baseload operation. In addition, existing peaking power stations utilisation in this scenario is very high at levels above 80% as in shown in Annexure B.

- REFERENCE (SCENARIO TWO)

  This scenario considers supply side initiatives in Scenario One including initiatives by business with commercial operation date and location as well as public procurement initiatives undertaken by the DMRE through the IPP Office.

  Results of this scenario indicate that unserved energy remains high under this scenario with marginal improvement due to slightly higher supply side initiatives. The outcomes of this scenario also indicated that utilisation of peaking power stations remaining high at levels above 80%.

- FIRM INITIATIVES AND ALL INITIATIVES (SCENARIO THREE)

  This scenario considers all supply side initiatives by business as well as public procurement initiatives up to Bid Window 7 as undertaken by the DMRE through the IPP Office.

  Under this scenario, the results indicate a further improvement in unserved energy is observed from year 2028 compared to the second scenario. However, unserved energy levels remain high with peaking power stations utilisation also remaining high.

- FIRM INITIATIVE AND GAS (SCENARIO FOUR)

  This scenario considers supply side initiatives in Scenario One including gas to power initiatives by Eskom and the DMRE through the IPP Office.

  The results indicate that for the period up to year 2027, the power system remains constrained as supply side initiatives deployed are not adequate to eliminate unserved energy and restore security of supply. From year 2027, additional supply side initiatives in the form of new dispatchable gas restores security of supply with low or unserved energy. Notably, the utilisation of existing peaking power stations reduces to 30% which is still generally high.

- FIRM INITIATIVES AND RECOVERY (SCENARIO FIVE)

  This scenario considers supply side initiatives in Scenario One including EAF recovery (higher EAF).

  The results of the scenario indicate that security of supply is fully restored with immediate effect and existing peaking power stations utilisation reduces to acceptable levels in the study period, except for 2030 when a significant coal-fired capacity is shut down.

5.2 Overall Observations

The overall observation from the analysis of the scenarios analysed under Horizon One indicate that the different electricity generation initiatives or projects currently being implemented will contribute to reducing unserved energy but they must include dispatchable capacity. This is because of the inherent characteristics of the South African power system and the erratic performance of existing coal fired power plants. The system requires generation options that are of a similar characteristic to replace the lost dispatchable capacity as and when the failures occur.

Improvement in EAF and deployment of gas to power provides these options to the system and hence low or no unserved energy is observed for Scenarios Four and Five.

The emissions analysis for Horizon One indicate that carbon emissions are within the National Determined Contribution (NDC) until 2025 and thereafter begin to show a decline below the nationally determined threshold as depicted in Figure 21.

Overall, the above analysis for Horizon One leads to emerging plan as captured in Table 2. The plan includes expected capacity from the last two remaining units of Kusile, government programmes currently procured up to BW 6, committed and priority projects by the business community, forecasted roll out of rooftop solar PV by both the commercial and residential sector. The emerging plan also shows need for new additional capacity solar PV, wind and dispatchable capacity with high utilisation factor. While not reflected in emerging plan, it is expected there will be more solar PV and wind capacity from business community that will come online post year 2027.

Table 2: Emerging Plan from Horizon One Analysis

	Coal	Gas – IPP Programme	Gas - Eskom	Dispatchable Capacity	Nuclear	Hydro	Pumped Storage	CSP	Solar PV	Wind	Hybrid IPP Programme	Distributed Generation[k]	BESS – IPP Programme	BESS - Eskom	Unserved Energy (TWh)
Current Base (MW)	38 800	1 005	2 825	-	1 860	1 600	2732	500	2 287	3 443	-	5 000	-	20	
2024	720							100			150	900		199	13.06
2025	720	1 220							2 115	644	476	900	513	141	7.63
2026										140		900			7.66
2027		1 000								684		900	2 000 615		4.55
2028		1 000	3 000						500			900	615		0.22
2029									500	1 500		900			0.25
2030		1 000		1 376					500	1 500		900			0.27
Additional New Capacity (MW)	**1 440**	**4 220**	**3 000**	**1 376**				**100**	**3 615**	**4 468**	**626**	**6 300**	**3 743**	**360**	

	Installed Capacity
	Capacity under construction
	Capacity procured
	New Capacity
	Distributed Generation Capacity for own use
	Unserved Energy, preferred as low as possible

5.2.1. Proposed Interventions

Intervention 1: As already identified and in progress as part of the Energy Action Plan interventions, the improvement of Eskom fleet EAF as per the Generation Recovery Plan is crucial and will make a significant contribution in restoring security of supply.

Intervention 2: In addition to non-dispatchable supply initiatives (business plus the State), the deployment of dispatchable generation options such as gas to power in line with Section 34 Ministerial Determinations must be accelerated as they will address the unserved energy risk and can be adapted to the power system requirements in a relatively short time.

Intervention 3: Where technically and commercially feasible, delay shutting down coal fired power plants to retain dispatchable capacity.

Intervention 4: Support and enable the development of the transmission grid as per the TDP 2023-2032 to enable connection of additional generation capacity initiatives by the public and private sector,

Intervention 5: Manage the following emerging risks:

- Completion of Extension of the design life of Koeberg Power Station
  Completion of the planned life extension of the Koeberg nuclear power station should proceed with the necessary speed to mitigate against the loss of dispatchable 1 800 MW.
- Compliance with Minimum Emissions Standards
  Resolving the challenges around compliance with the implementation of the Minimum Emissions Standards (MES) on coal fired power stations in terms of the National Environmental Management: Air Quality Act 39 (2004) is critical as it will drastically ensure capacity totalling 16 000 MW immediately and up to 30 000 MW in April 2025 is retained.

6. Analysis of Horizon Two (Period 2031 – 2050)

The modelling of Horizon Two analysed five energy mix pathways aimed at informing the country's policy choices or decisions for a secure and sustainable energy. The pathways tested a combination of generation sources such as wind, solar PV, Energy Storage System, gas, nuclear and cleaner coal technologies to understand the extent to which they ensure security of supply while reducing carbon emissions in line with the country's path towards net-zero.

The reference pathway established a benchmark against other pathways against other pathways on the least cost and did not consider any implementation constraints. Pathways were compared considering security of supply, overall system costs and minimising the cost of unserved energy to the economy. The five pathways developed are detailed in Figure 11.

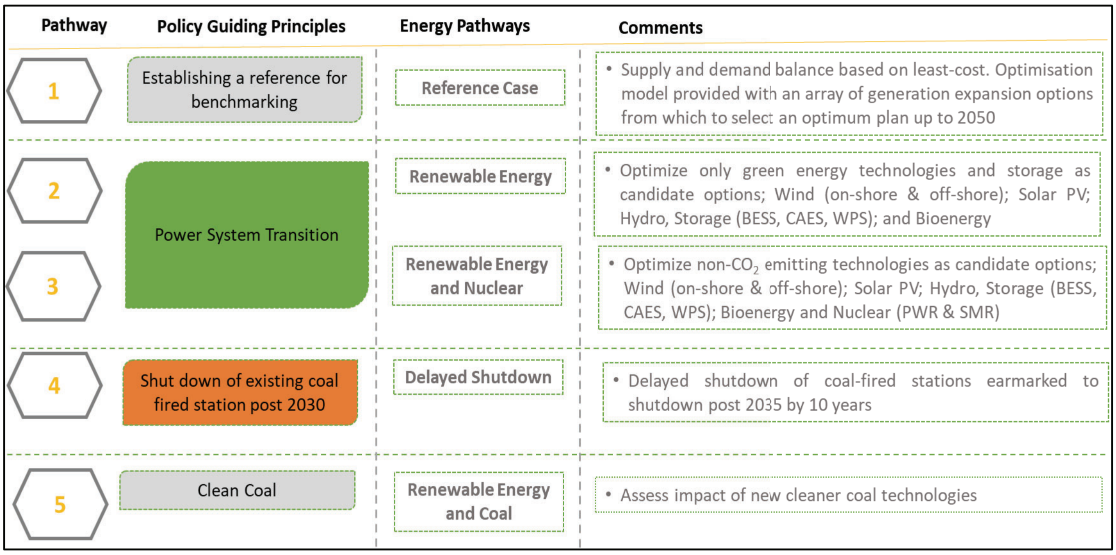

Figure 11: Horizon Two Energy Pathways

6.1 Results from Analysis of Horizon Two

This section outlines and summarise the results from the analysis of pathways considered for Horizon Two. Detailed results and analysis are contained in Annexure C.

- PATHWAY ONE (REFERENCE CASE)

  This pathway which is a reference case is based on simulation output based on least cost energy mix.

Results of this scenario demonstrate a very large build consisting mainly of Solar PV, Wind and Gas at mid merit or higher utilisation. The results also indicate a significant build requirement by year 2035 which is over a decade away. From a security of supply perspective, the energy mix from this pathway is adequate.

Initially, the results of the pathway show significant reduction in carbon emissions mainly driven by the shutdown of coal fired plants and their replacement with renewable energy and gas. Emissions show an increasing trend from 2042 as gas utilisation significantly increases due to high demand projection from around year 2041.

The pathway is least cost as the model is allowed to choose technology combinations without any restrictions.

- PATHWAYS TWO AND THREE (TRANSITIONING THE POWER SYSTEM)

These pathways sought to explore the impact on security of supply based on a policy on the deployment of renewable and clean technologies. For Pathway Three, Gas fired options are only allowed up to 2033 before the earliest assumed availability of nuclear technologies. Pathway Two excludes gas but considers battery storage, water pumped storage and bioenergy to support renewable energy.

Pathway Two builds the most generation capacity by 2050 compared to all other pathways and this is due to low load factor and non-dispatchable characteristic of renewable energy. From security of supply perspective, the two pathways have the highest security of supply inadequacy (unserved energy). The two pathways have the least carbon emissions over the study period up to 2050.

The renewable energy only pathway has the highest cost compared to the other pathways. The nuclear pathway costs are also higher than those from the reference pathway.

- PATHWAYS FOUR (DELAYED SHUTDOWN)

  This pathway was formulated based on delaying coal fired plants shutdown by ten years. For the simulation, power stations used for the delayed shutdown were those with end of design life post year 2035 totalling about 15 000 MW.

  Delaying shutdown has the lowest new build requirements and adequately maintain security of supply.
  The results indicate that delaying shutdown without retrofit with abetment will result in carbon emissions reaching levels similar to those around year 2026.

- PATHWAY FIVE (CLEANER COAL TECHNOLOGIES)
  This pathway is premised on deployment of cleaner coal technologies, and these include a combination of fluidised Bed Combustion (FBC) and pulverised fuel technologies with CCUS. The analysis capped new coal deployment at no more than 6 000 MW during the study period.

  This pathway results in the second least build requirements with additional renewable energy, gas, and storage. From security of supply, this pathway is marginally inadequate. The results indicate the pathway has the second least cost new build requirements, and has low emissions compared to the reference pathway.

6.2 Overall Observations

- In this study period it is evident that energy pathways based on renewable and clean energy technologies only deliver the desired outcome in so far as decarbonising the power system. However, these pathways do not provide security of supply while carrying the highest cost to implement.

- In the period between 2031 to 2050 the system will require a massive new build programme with significant capacity required in just over a decade from now. The implication of this is that implementation of generation capacity required for this horizon including associated transmission network must begin in earnest.

- Pathways comprising of dispatchable technologies with high utilisation factor provide security of supply. Other than delayed shutdown, these technologies include different combinations of nuclear, renewables, clean coal and gas. Notably these pathways support the carbon reduction commitments.

- It is evident from the analysis done and observations above that post 2030 pathway that will ensure security of supply, reduce carbon emissions, and ensure least cost to the economy will be a combination of technical analysis (power system modelling and simulation) and policy adjustment that considers practical implementation considerations.

7. Conclusion

This IRP Review presents an analysis of broad options at the disposal of the country with the ultimate view to meet three distinct but not mutually exclusive aspirations, namely, security of supply, energy affordability and carbon emissions reduction. Analysis of the period between now and year 2030 highlights a concerning electricity supply and demand deficit. While ongoing additional generation capacity initiatives are expected to alleviate unserved energy, they do not fully address the underlying system adequacy.

Generation pathways and options studied indicate that firm decisions based on system requirements are crucial, however, these options are met with policy tensions which require balanced decision making. The final policy decisions must be taken on the basis of a long term decarbonisation trajectory while improving South Africa's competitiveness, growing the economy through an industrial renaissance as outlined in the NDP.

8. References

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9. Annexures

ANNEXURE A: Grid Capacity availability in the Cape for Years: 2024, 2027 and 2030

To determine grid capacity available for connection of new generators in the heavily constrained supply areas of the Cape, the IRP 2023 assumed the following criteria for the reference case:

- All projects that are under construction as of June 2023.
- Projects that have reached financial close, have EIA approvals; and
- Projects that have been allocated grid capacity.

This criterion freed up grid capacity in different provinces to guarantee accommodation of shovel ready generation projects as depicted in Figure 12 and removal from the grid of projects that do not meet the above criteria. The development of the transmission grid until 2032 as per the TDP is considered and enables more generation capacity to be connected to the grid.

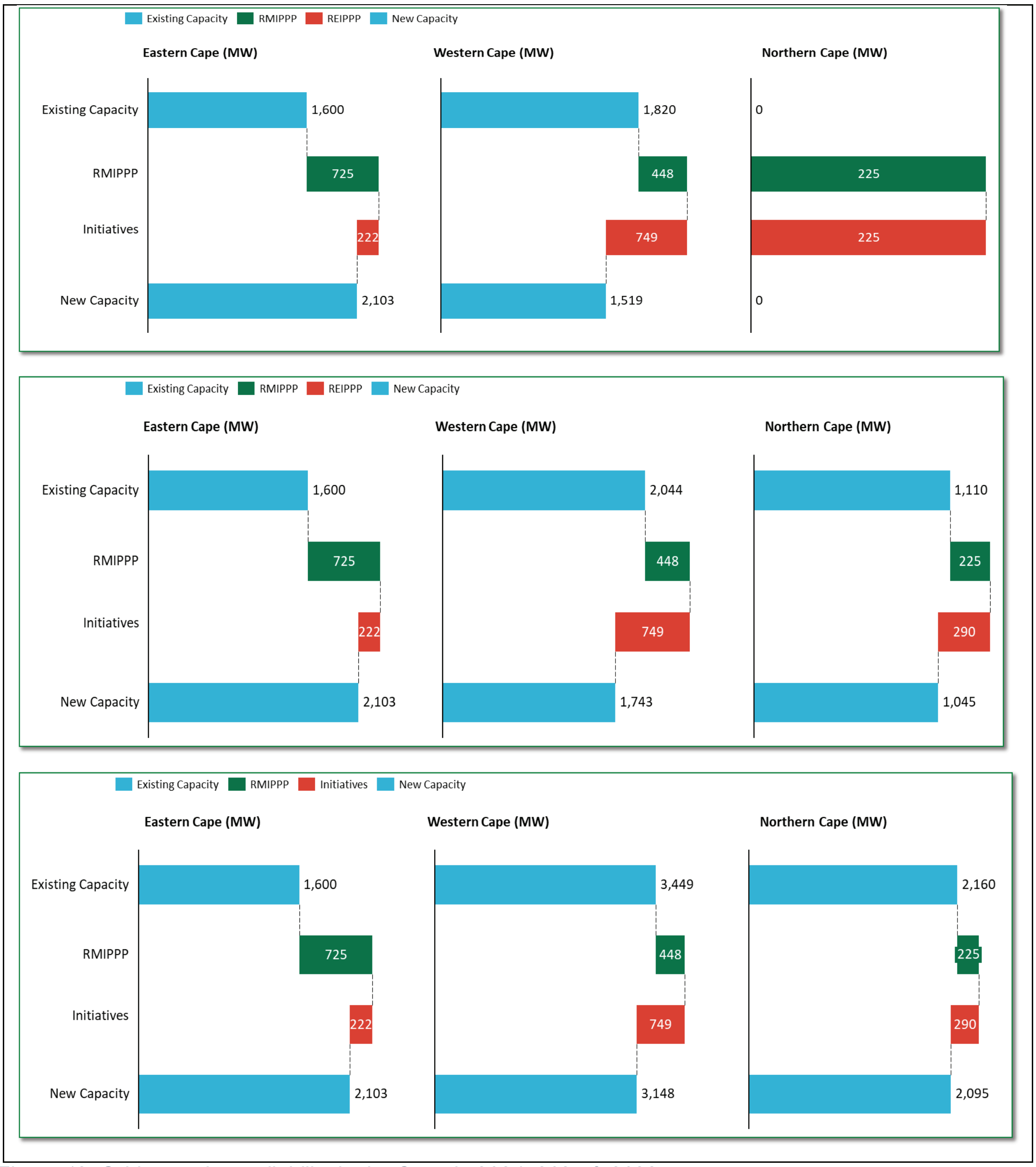

Figure 12: Grid capacity availability in the Cape in 2024, 2027 & 2028

Annexure B: Peaking power stations utilisation (%) in Horizon One

This annexure details the utilisation of peaking power stations for Horizon One (Period 2023 to 2030)

Existing gas utilisation is a weighted average of Acacia, Ankerlig, DMRE Peakers, Gourikwa and Port Rex. New Gas refers to the DMRE REIPPPP Gas, Eskom Richards Bay and RMIPPPP Gas.

Table 3: Existing Gas Utilisation Factors

Sensitivity		2023	2024	2025	2026	2027	2028	2029	2030
Reference		77.50	78.79	72.49	70.38	71.14	77.14	79.57	87.86
Reference + High-Likelihood Initiatives		77.50	78.79	72.43	70.48	71.14	77.14	79.57	87.86
Reference + All Initiatives		77.53	78.75	72.49	70.38	70.83	69.06	63.69	80.30
Reference + Gas	Existing Gas	84.44	87.04	84.47	87.73	85.11	18.03	25.85	73.38
	New Gas	-	-	-	42.50	65.77	72.88	76.44	86.71
Reference + Recovery		26.31	2.65	1.60	2.00	2.69	5.81	10.52	46.90

Annexure C: Detailed Technical Results for the Analysis of Horizon Two (Period 2031 – 2050) Pathways

This annexure provides further analysis conducted for Horizon Two and details capacity expansion plans, unserved energy, carbon emissions and system costs for energy pathways.

a) Reference Case (Pathway One)

The analysis of this pathway revealed new capacity required to restore security of supply for the period up to 2035, is as follows:

- Mid-merit gas (CCGT), of more than 7 000 MW,
- 4 500 MW of wind,
- More than 4 000 MW of PV and 2 000 MW of BESS.

In the period between 2036 and 2050 more than 15 000 MW of CCGT, more than 30 000 MW of wind and 10 000 MW of BESS are required as Figure 13.

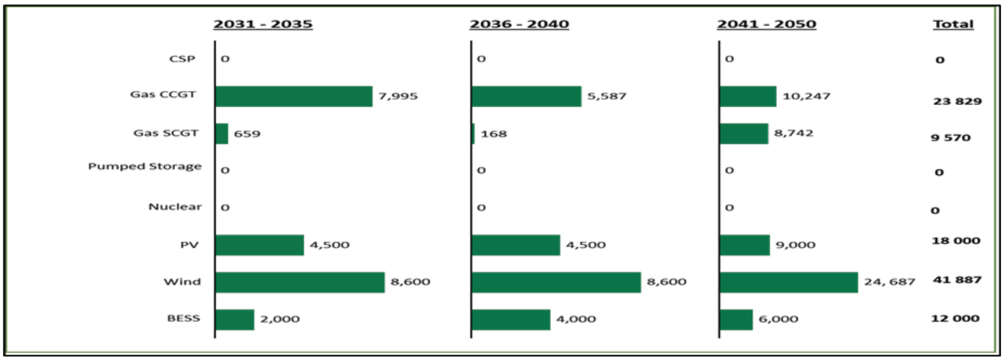

Figure 13: Reference Energy Pathway new generation capacity

b) Renewable Energy (Pathway Two)

This pathway exhibits the highest total new build capacity of 166 000 MW by 2050, as indicated in Figure 14. This capacity comprises wind, solar, gas and storage.

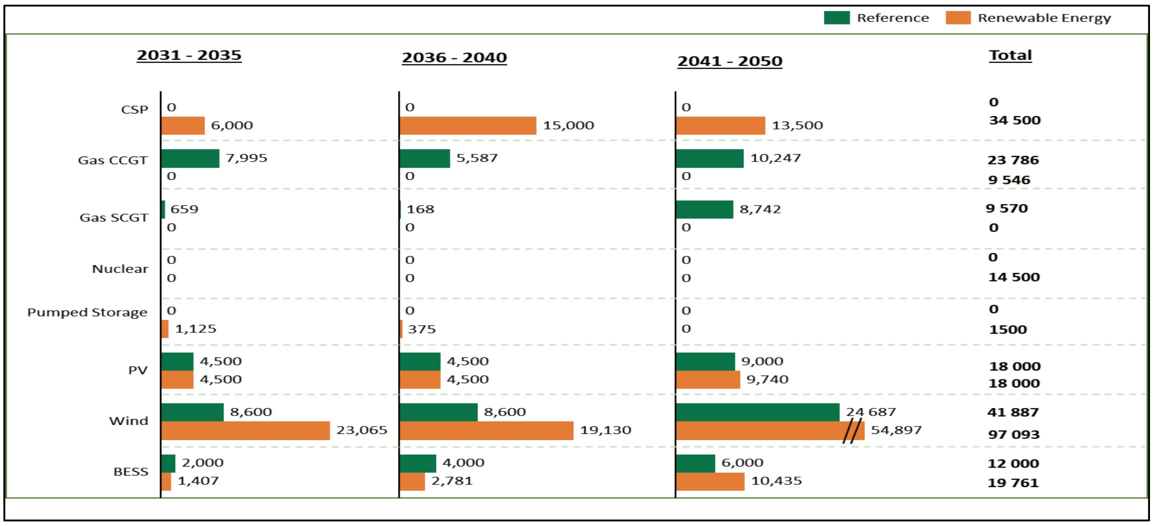

Figure 14: Pathway Two results

c) Renewable Energy & Nuclear (Pathway Three)

The analysis of this pathway yielded a total capacity of 4 000 MW of new nuclear by 2040 with additional nuclear capacity of up to 14 500 MW by 2050. Notably, the pathway results depicted significant new wind capacity of 67 000 MW and 14 000 MW of BESS as shown in Figure 15.

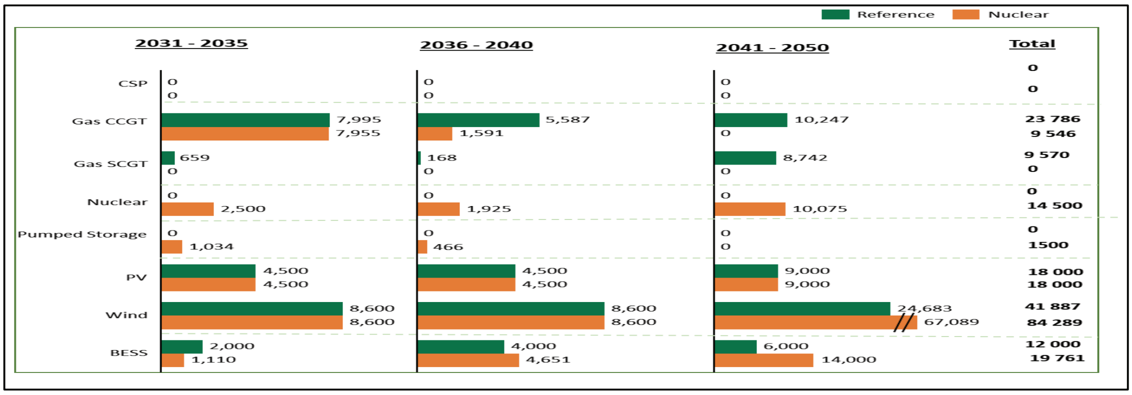

Figure 15 Pathway Three results

d) Delayed Shutdown (Pathway Four)

To be more conservative in quantifying the extent to which the Generation Recovery Plan positively addresses security of supply in this pathway, the IRP Review sees it prudent to assume a slower EAF recovery scenario that improves towards the high EAF scenario from 2031.

The result, based on the magnitude of the units of these stations, is an improvement of the EAF that goes above 70% from 2036 as shown in Figure 16.

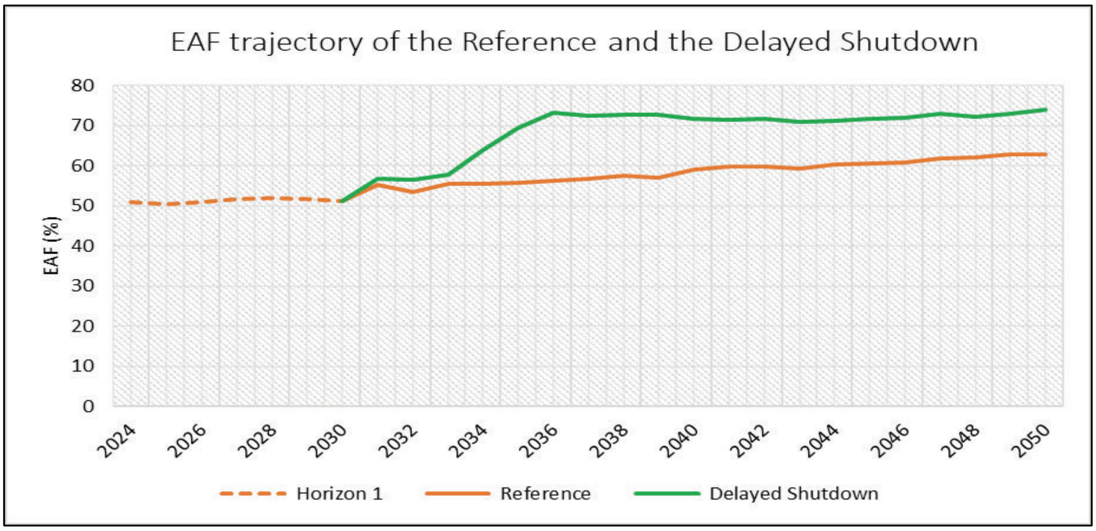

Figure 16: EAF improvement assumptions for the Delayed Shutdown Pathway

The analysis of this pathway shows a total new generation capacity requirement of 4 000 MW of CCGT by 2040 as indicated in Figure 17. This is due to the assumed delayed shutdown of the five stations. This reduces the requirement for a high utilisation gas by approximately a third of the Reference Pathway requirement. Further, there is no BESS capacity requirement compared to the 6 000 MW in the Reference Pathway.

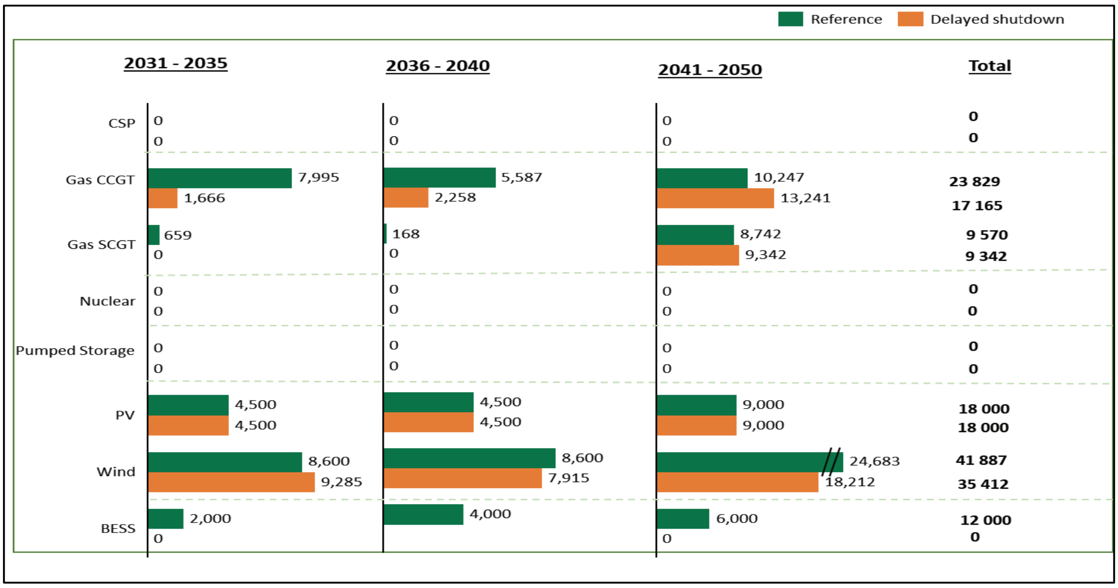

Figure 17: Coal Delayed Shutdown Pathway New Build Plan

e) Renewable Energy & Coal (Pathway 5)

Results from the modelling of this pathway shows new coal capacity of 5 000 MW on the basis of new clean coal technologies by 2040. In addition, this scenario highlighted 60 000 MW of wind capacity by 2050 as shown in Figure 18. No new BESS capacity is required in this Pathway.

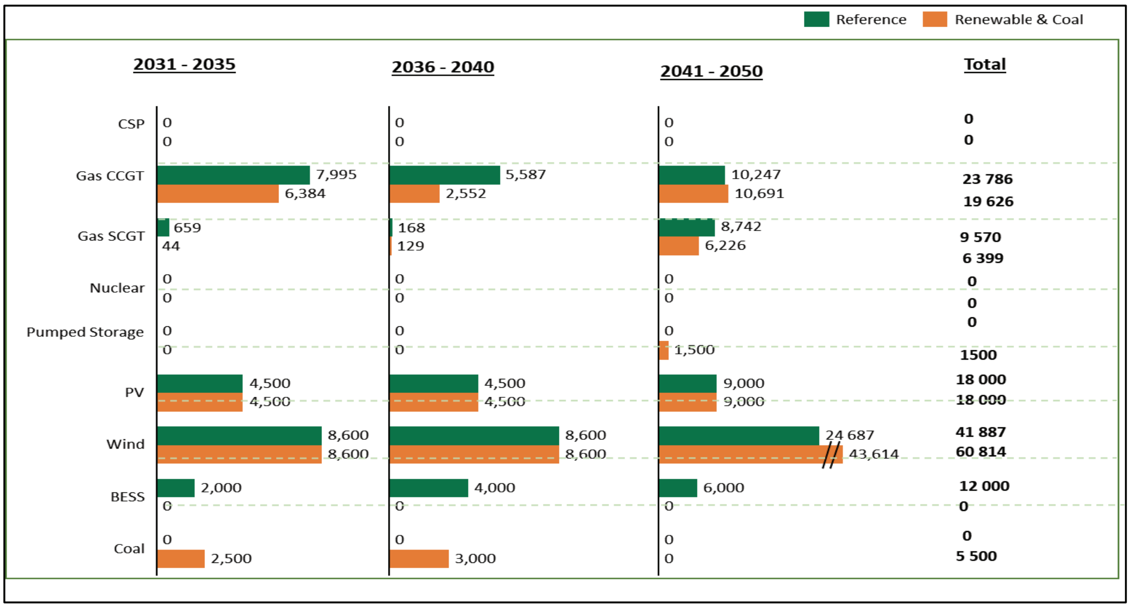

Figure 18: Pathway Six results

Overall new build observations

A summary of additional new build capacity across the different Pathways is shown in Figure 19.The following observations are made:

- The Least Cost Plan builds 105 000 MW whilst the Renewable Energy Pathway required 166 000 MW of new capacity.
- Both the Delayed Shutdown Pathway; and the Delayed Shutdown and Repowering build 80 000 MW of new capacity by 2050 which happens to be the least amount of new capacity in this period.
- Only the Renewable Energy Pathway builds new CSP capacity.
- Only the Renewable Energy, the Renewable Energy and New Nuclear; and Renewable Energy and Coal Pathways build new water pumped storage technology.

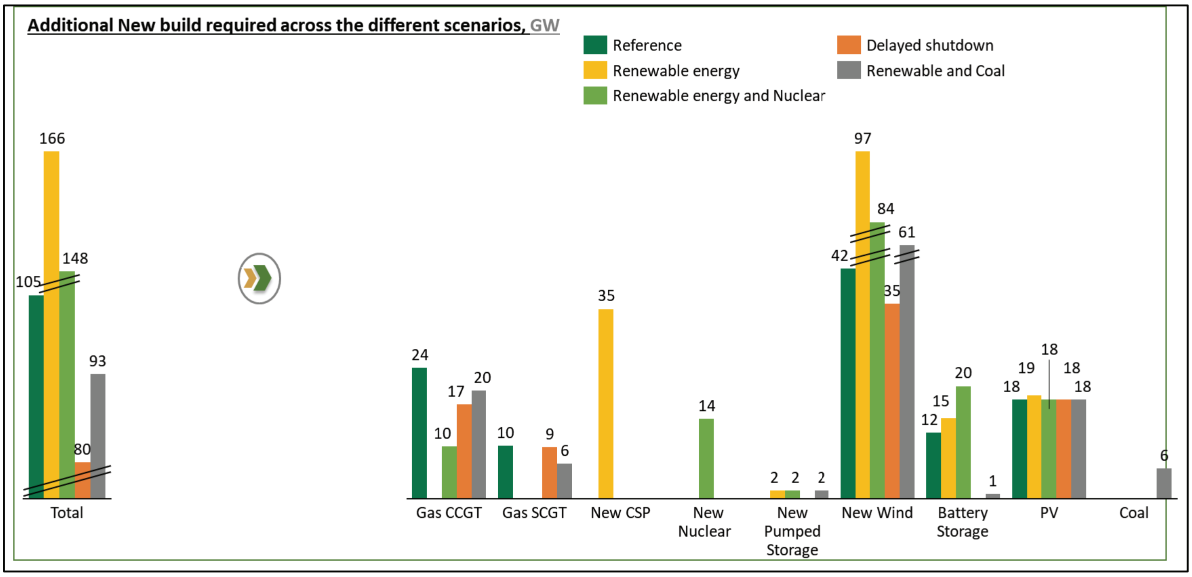

Figure 19: Summary of new build for each pathway

Unserved Energy of Pathways

This section summarises the security of supply positions emanating from the different pathways studied in this period (See Figure 20):

- The system transitioning pathways that are mainly focusing on decarbonising the power system do not provide security of supply.
- All other pathways restore security of supply from 2031 to 2050.

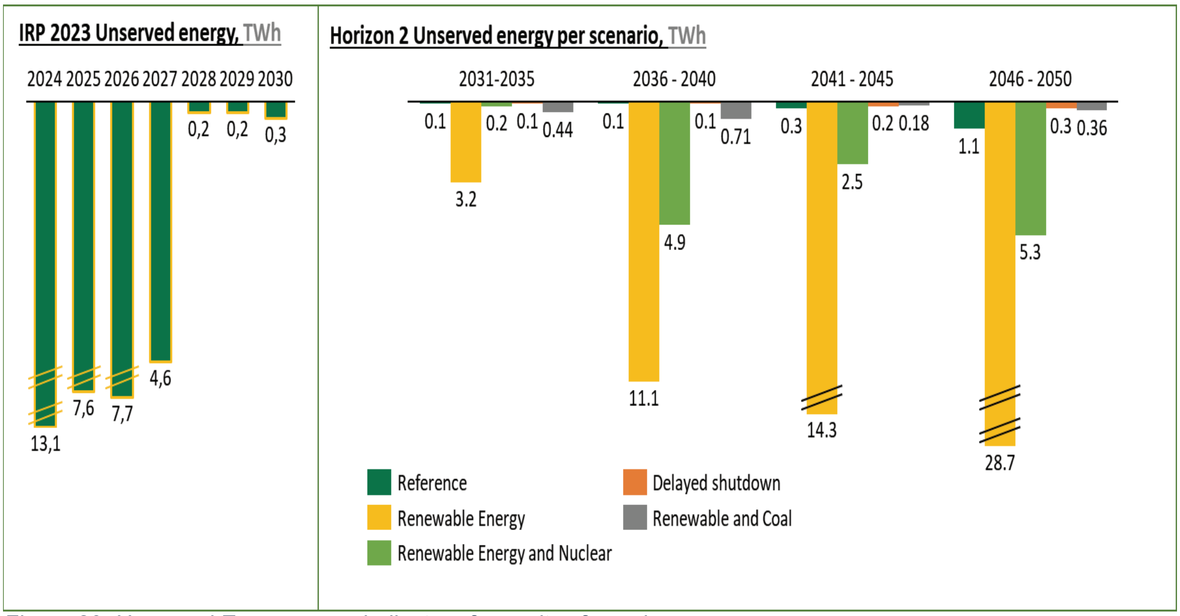

Figure 20: Unserved Energy as an indicator of security of supply

Carbon Emissions for Pathways

Energy production of the different Pathways with their associated emissions are shown in Figure 21 and lead to the following observations:

- The emissions analysis for Horizon One indicate that carbon emissions are within the National Determined Contribution (NDC) until 2025 and thereafter begin to show a decline below the nationally determined threshold.
- In the delayed shutdown and repowering analysis, the study indicated that carbon emissions remain high throughout the study period.
- Overall, the transitioning of the power system delivered the lowest carbon emissions.

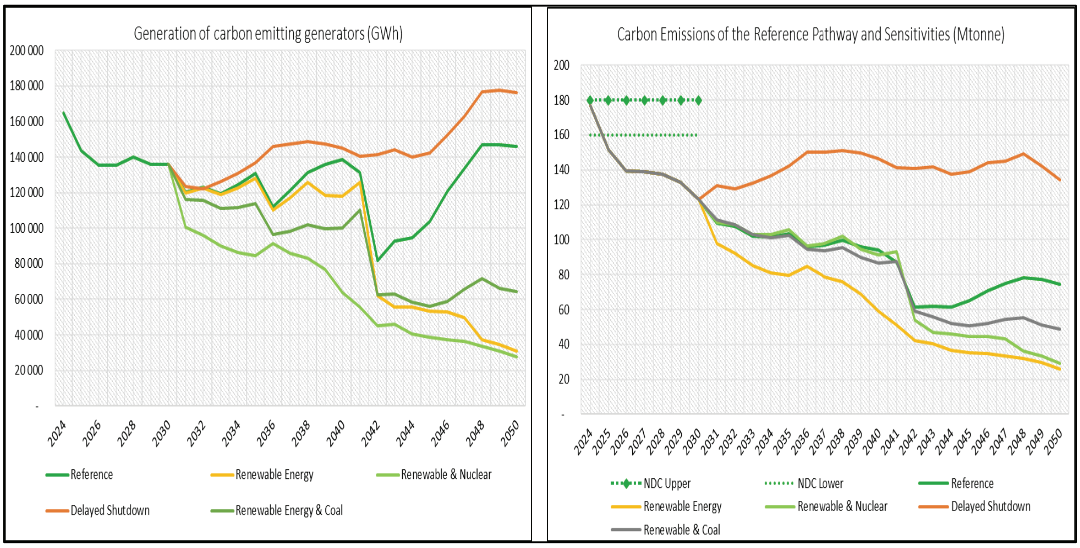

Figure 21: Carbon Emissions Analysis for both Horizons

Overall System Costs

The net present value costs of the different pathways, indicated in 2024 monetary terms, show the following observations (see Figure 22):

- The reference pathway indicates the lowest total system costs.
- The results of the transitioning pathways show that these pathways have high costs due to high unserved energy and new build costs.

- Due to the magnitude of their total system cost differences, the renewable and nuclear, the delayed shutdown; and repowering warrant further techno-economic studies to ascertain their cost structures.

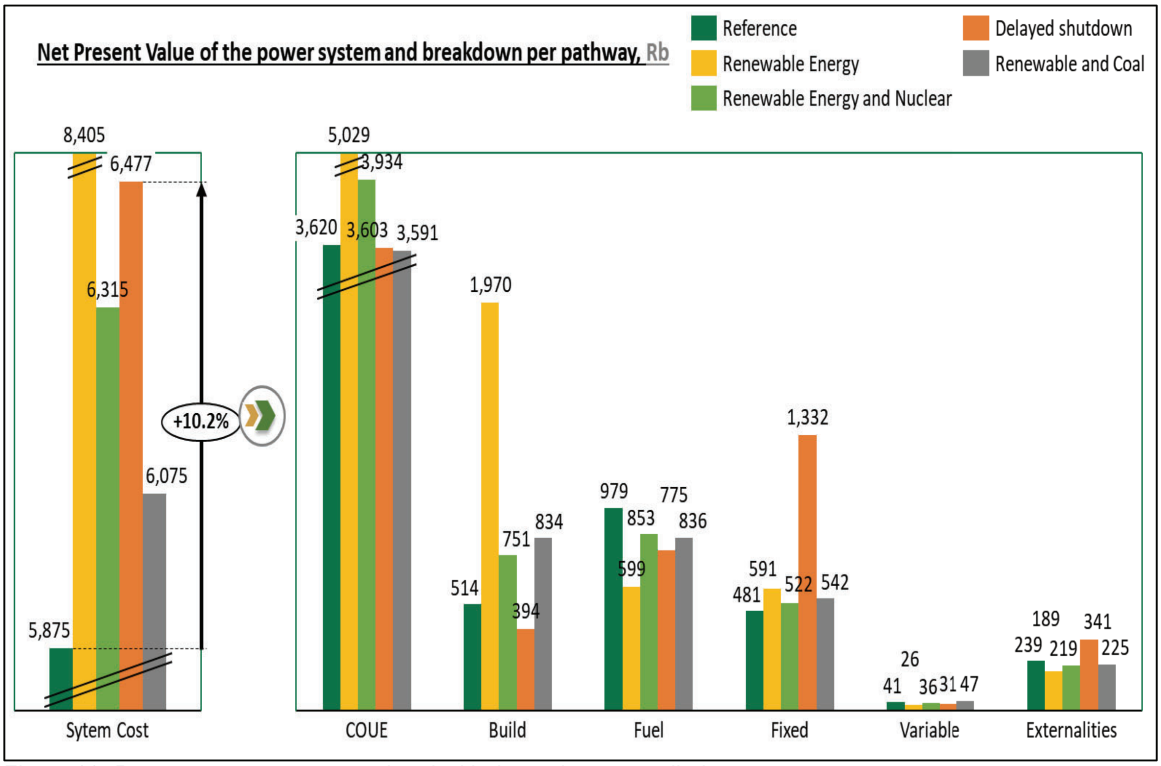

Figure 22: Power system costs associated with the pathways studied

Annexure D: Impact of Delayed Shut Down on Coal fired Stations.

Delaying the shutdown of five key stations whose end of life is post 2035 results in more than 8 000 MW by 2050 compare to the Reference as shown in Figure 23.

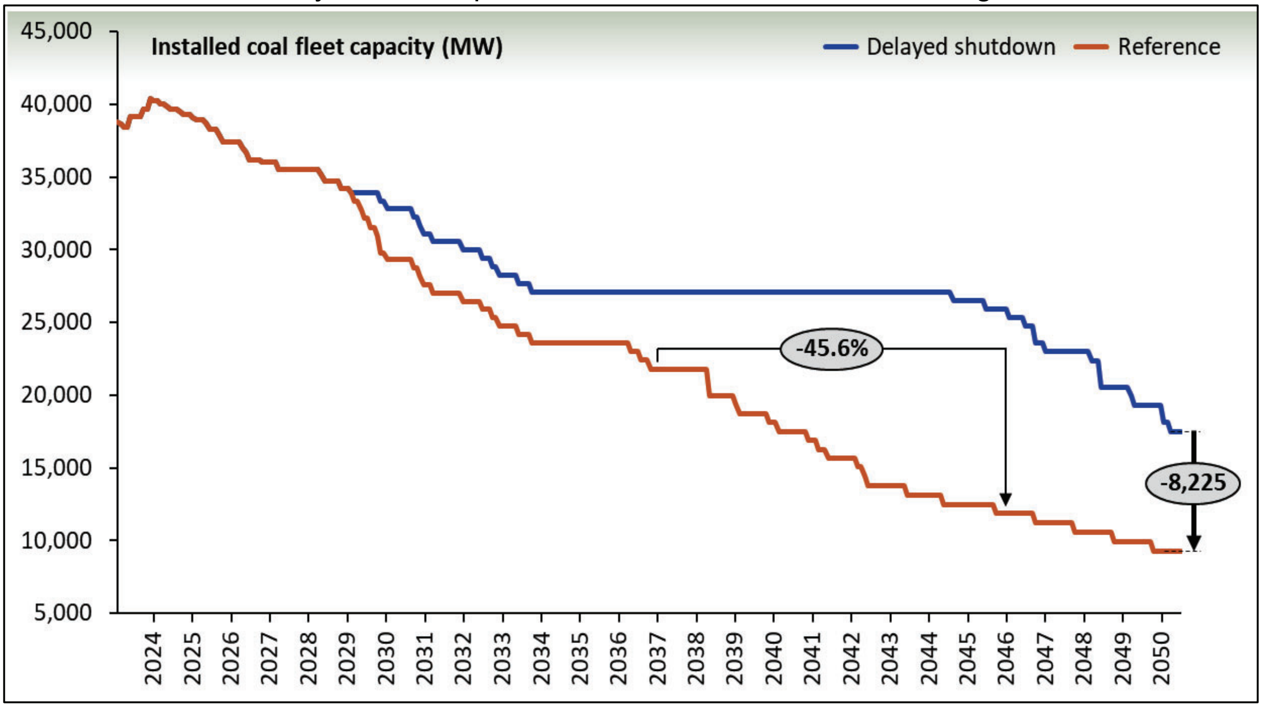

Figure 23: Impact of delayed shutdown on installed capacity

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