Eskom
National Transmission
Company South Africa ™

Medium-Term System Adequacy Outlook 2025-2029

Generation System Adequacy for the Republic of South Africa

30 October 2024

PURPOSE

The System Operator publishes the Medium-Term System Adequacy Outlook (MTSAO) under clause 2.1.2 (7) of the South African Grid Code, System Operation Code Version 10.1 of January 2022 which requires the System Operator (SO) to publish it on or before 30 October each year. The study is a review of the adequacy of available, committed and anticipated electricity generation resources to meet the South Africa's forecasted electricity demand in the upcoming 5 years. This publication aims to provide electricity consumers and all relevant stakeholders with an update on the state of the power system and to anticipate potential scenarios based on available data, forecasts and assumptions. The study is not intended to be used as either a generation resource plan or an operation plan, but rather serves as an indicator of the adequacy of the generation system under a range of different future scenarios and sensitivities.

DISCLAIMER

While the System Operator has taken reasonable care in the collection and analysis of data, forecasts and assumptions, the System Operator is not responsible for any loss that may be attributed to the use of this information from unforeseen circumstances that may arise from the continually changing South African energy industry. Before making any business decisions, interested parties are advised to seek separate and independent opinions in relation to the matters covered by this report and should not rely solely on data and information contained herein. Information in this document does not amount to a recommendation in respect of any possible investment. This publication is generally based on information available to the System Operator as at August 2024, unless otherwise indicated.

The MTSAO does not make recommendations regarding specific technology types or capacity sizes required to bridge the energy gap where it exists, as this responsibility lies within the jurisdiction of the Integrated Resource Plan (IRP) process. It also does not evaluate the adequacy of the grid to transport and distribute generated electricity as this responsibility falls under the scope of the Transmission Development Plan (TDP) process. Therefore, the details of the location of any supply shortages that may be localised because of the pattern of supply loss and how it interacts with the transmission and/or distribution system are not assessed.

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ABBREVIATIONS

Term/Abbreviation	Definition
BESS	Battery Energy Storage System
BWs	Bid windows
BQ	Budget quote
CSP	Concentrated solar power
DER	Distributed energy resources
DFFE	Department of Forestry, Fisheries and Environment
DoEE	Department of Electricity and Energy
EAF	Energy availability factor
GDP	Gross domestic product
GW	Gigawatt
GWh	Gigawatt-hour
IPP	Independent power producer
IRP	Integrated Resource Plan
MES	Minimum emission standards
MTSAO	Medium-Term System Adequacy Outlook
MW	Megawatt
NERSA	National Energy Regulator of South Africa
NNR	National Nuclear Regulator
OCGT	Open-cycle gas turbine
PV	Photovoltaic
REIPPP	Renewable Energy Independent Power Procurement Programme
RFP	Request for proposal
RMIPPPP	Risk Mitigation Independent Power Producer Procurement Programme
SAGC	South African Grid Code
SO	System Operator
SSEG	Small-scale embedded generation
TDP	Transmission Development Plan
TWh	Terawatt-hour

1. EXECUTIVE SUMMARY

The Medium-Term System Adequacy Outlook (MTSAO) is a generation assessment that measures the ability of the electric power system to meet demand over the next 5 calendar years within acceptable levels of reliability using predefined adequacy metrics. The current MTSAO for the period 2025 to 2029 calendar years, hereinafter referred to as the MTSAO 2024, considered the following key assumptions:

Demand assumptions:

- Moderate demand scenario which assumes a GDP growth rate of 2.2% and forecasts an average annual energy demand increase of 1.1% over the 5-year study period.
- High demand scenario which assumes a GDP growth rate of 2.5% and projects a higher average annual energy demand growth of 1.6% over the 5-year study period.

Plant performance assumptions:

- High EAF scenario, a moderately optimistic scenario which represents a moderately optimistic recovery of EAF levels and is based on partial recovery initiatives. This scenario reflects an annual average EAF of 63% over the study period.
- Low EAF, which represents a position where recovery initiatives are unsuccessful in turning around the historical EAF trend. This scenario is aligned with the draft IRP 2023 and shows a declining performance with an annual average EAF of 50% over the study period.

New Capacity assumptions:

- Committed capacity - consisting of projects that have reached financial close and are either in construction or in the process of finalising their designs to enter the execution stage.
- All new capacity – includes all the projects from various stages of development that are in the pipeline within the 5-year study period.
- Risk adjusted capacity - narrows the focus to those projects with a stronger probability of achieving commercial operation, despite their current phase in the development pipeline.

5 scenarios namely the base case, all new capacity, the risk adjusted new capacity, the high demand and low EAF were developed based on the above assumptions.

The results of the MTSAO 2024 modelling indicate the following:

- Though the high EAF shows moderate plant performance improvement, the system remains adequate at that EAF.

- The low EAF scenario which shows a declining EAF, emphasises the importance of maintaining good plant performance as the drop in EAF will take the country back to the constrained system and possible load shedding.
- The scenario with all new additional capacity presents a new challenge in the form of excess energy on the system.

The study thus recommends that:

- A continued focus on plant performance improvement and ensuring that the high EAF levels are sustained.
- Ensuring that Kusile unit 06 and Medupi unit 04 become operational according to their planned dates. These are two big base load units with a big impact on the system, their delays will negatively impact the system, and hence it is important for system adequacy that they are not delayed.
- The impact of additional renewable energy capacity on the grid needs to be studied and understood. Understanding the impact that these additional renewables have on the grid stability will enable SO to put measures in place that ensures the system remains resilient and stable.

2. INTRODUCTION

The Medium-Term System Adequacy Outlook (MTSAO) evaluates the power system's ability to meet electricity demand within predefined adequacy thresholds over the next 5 calendar years, as required by the South African Grid Code (SAGC: System Operator Code, January 2022). The current assessment, which is referred to as MTSAO 2024, covers the calendar years 2025 to 2029. The assessment is limited to the identification of possible electricity supply surpluses or shortfalls and its outcomes have the following key implications:

- It serves as a foundational reference point for policy makers in the decision making of procurement of power generation resources. Specifically, it provides insight into whether current generation capacity is sufficient to meet demand or if additional resources need to be acquired.
- It informs the general public about possible generation shortfalls or surpluses and associated risks. This includes providing stakeholders with insights into the extent and timing of supply risks, such as the amount of unserved energy or excess energy that may need to be curtailed.

The study does not make recommendations regarding specific technology types or capacity sizes required to bridge the energy gap where it exists, as this responsibility lies within the jurisdiction of the Integrated Resource Plan (IRP) process. It also does not evaluate the adequacy of the grid to transport and distribute generated electricity as this responsibility falls under the scope of the Transmission Development Plan (TDP) process.

3. METHODOLOGY

The MTSAO process is illustrated in Figure 1. It shows how the input data consisting of demand and supply inputs is assessed hourly to quantify potential generation surpluses or shortfalls over the next 5 calendar years. Due to the intermittent and unpredictable nature of certain parameters used in assessing system adequacy, the study employs the Monte Carlo simulation method to account for their inherent randomness. These parameters include demand forecast, wind generation, solar generation, and unplanned power plant outages. The Monte Carlo simulation method is a mathematical technique that leverages historical data to forecast potential future outcomes of uncertain events. The outcomes of this technique provide a range of probable results based on random samples, and the results of the MTSAO represent an average across all the samples. The number of samples defined is based on a balanced trade-off between simulation runtime, input-output convergence, and quality of results.

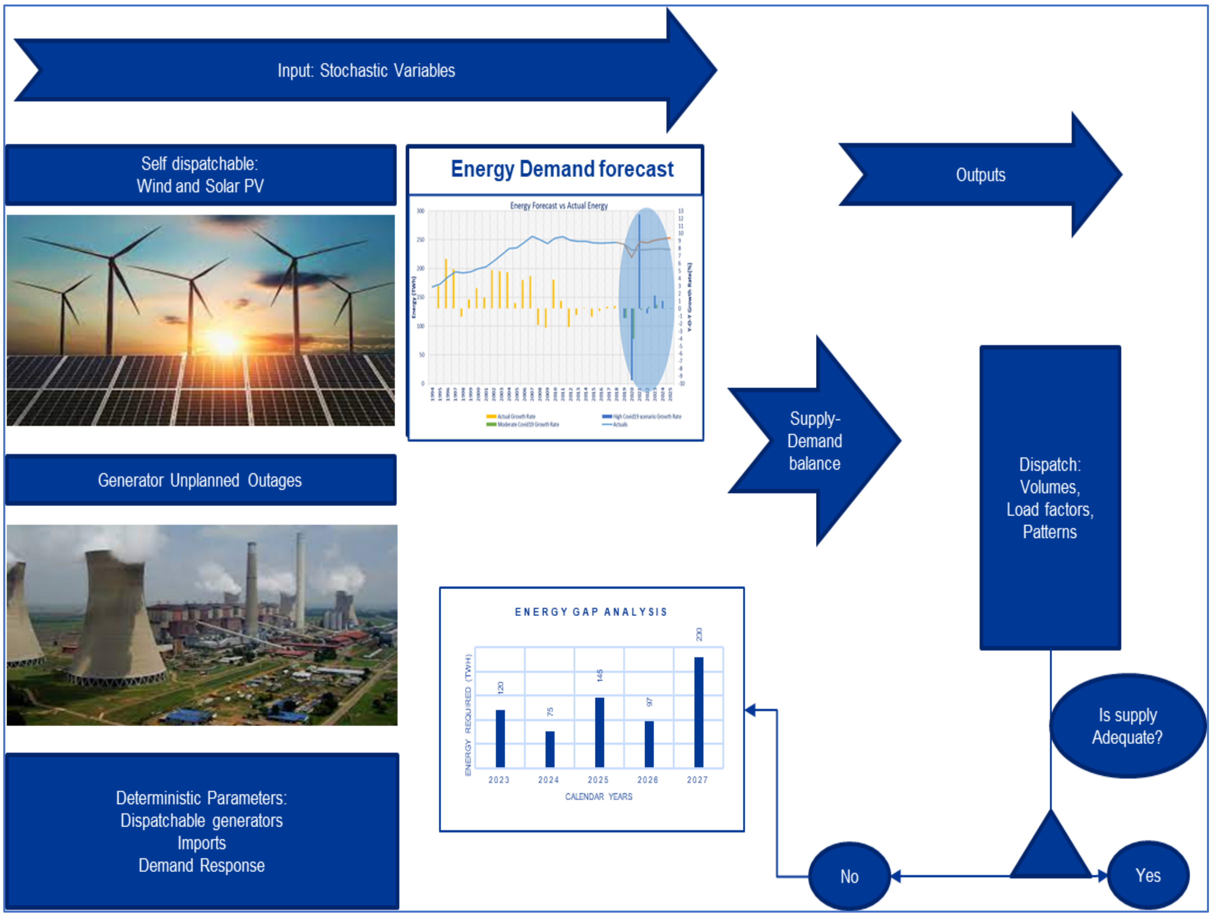

Figure 1: MTSAO methodology

The results of these Monte Carlo simulations are then reported annually to determine the extent to which the system meets or violates the adequacy metrics when dispatching available generators optimally. The electric power system is deemed to be adequate if it meets the following adequacy metrics:

i. The total amount of unserved energy per year is less than 20 GWh.
ii. The capacity factor of open-cycle gas turbines is less than 6% per year.

In the event of system inadequacy, an energy gap analysis is conducted to determine the total amount of additional energy needed to restore the power system to adequacy.

4. KEY ASSUMPTIONS

In doing the MTSAO study, the grid code requires the System Operator to consider the following:

- Possible scenarios for growth in the electricity demand, which includes both the South Africa's demand and exports to neighbouring countries.
- Possible scenarios for increases or decreases in available generation to meet the expected demand, inclusive of all licensed generators by the National Energy Regulator of South Africa (NERSA), imports from neighbouring countries, demand side management resources and Distributed Energy Resources (DERs).

- Possible scenarios for new generation projects, inclusive of sensitivity analysis on their likelihood of success.
- Any additional information that SO may reasonably consider relevant.

Hence the study considered a number of key assumptions which are detailed in the following sections. Due to the level of uncertainty surrounding both the demand-side and supply-side assumptions, a cone is provided, where possible, to assess a range of future realisations.

4.1 Energy Demand Forecast

The MTSAO study considered two demand scenarios namely the moderate and high demand. Both scenarios incorporate Gross Domestic Product (GDP) as a key input in econometric regression models to project South Africa's electricity demand, aligning with the anticipated economic growth of the country. The correlation between GDP and electricity demand is used through econometric modelling to forecast South Africa's electricity demand that will be needed to enable economic growth. The moderate demand scenario reflects a moderate economic growth for all economic sectors in the medium term. The high demand scenario is the upper cone of the moderate scenario and assumes favourable economic conditions in high electricity intensive sectors namely mining and industrial sectors. The scenarios are illustrated graphically in Figure 2.

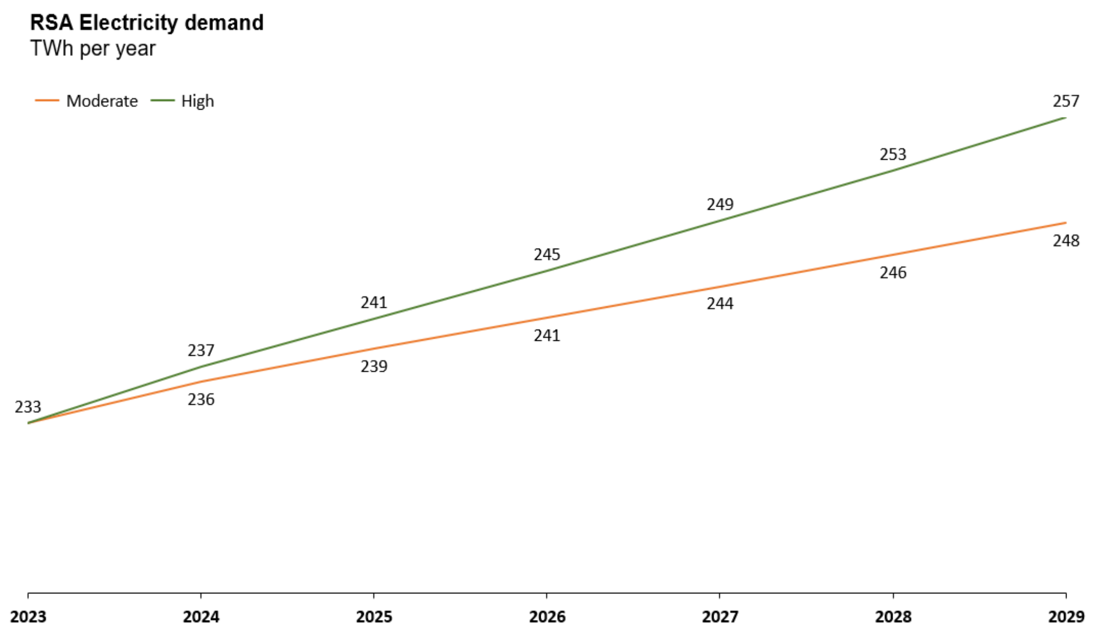

Figure 2: Energy demand forecast

The moderate demand scenario assumes a GDP growth rate of 2.2% and forecasts an average annual energy demand increase of 1.1% over the 5-year study period. Under this scenario, demand is expected to rise from 233 TWh in 2023 to 248 TWh by 2029. In contrast, the high demand scenario assumes a GDP growth rate of 2.5% and projects a higher average annual energy demand growth of 1.6%, with energy demand increasing from 233 TWh in 2023 to 257 TWh by 2029.

4.2 Reserve Requirements

The MTSAO not only assesses the ability of a generation power system to supply power to customers, but also includes the ancillary services requirements. The ancillary services are critical in maintaining system stability. The study relied on the Ancillary Services Technical Requirements report, which is published annually by the System Operator, to model the various types of reserves and the minimum provisions required from contributing generators or demand-side loads in the system. These reserves are briefly described below, and their respective minimum provisions are outlined in Table 1.

i. Instantaneous reserve: generating capacity or demand-side managed load that must be fully available within 10 seconds to arrest a frequency excursion outside the frequency dead band. This reserve response must be sustained for at least 10 minutes.

ii. Regulating reserve: generating capacity or demand-side managed load that is available to respond within 10 seconds and is fully activated within 10 minutes. The purpose of this reserve is to make enough capacity available to maintain the frequency close to the scheduled frequency and keep tie-line flows between control areas within schedule.

iii. Ten-minute reserve: generating capacity or demand-side managed load that can respond within 10 minutes when called on. It may consist of a quick offline start generating plant (for example, hydro or pumped storage) or demand-side load that can be dispatched within 10 minutes. The purpose of this reserve is to restore instantaneous and regulating reserves to the required levels after an incident.

iv. Emergency reserve: includes interruptible loads, generator emergency capacity, and gas turbine capacity. These requirements arise from the need to take quick action when any abnormality arises in the system.

v. Supplemental reserve: generating or demand-side load that can respond in 6 hours or less to restore operating reserves.

Table 1: Reserve requirement for seasonal peak and off-peak 2024/25 to 2028/29

Reserves	Season		2024/25	2025/26	2026/27	2027/28	2028/29
Instantaneous	Summer/Winter	Peak	650	650	650	650	650
		Off-peak	850	850	850	850	850
Regulating	Summer/Winter	Peak/Off-peak	650	725	800	875	950
Ten-minute	Summer/Winter	Peak	900	825	750	675	600
		Off-peak	700	625	550	475	400
Operating	Summer/Winter		2200	2200	2200	2200	2200
Emergency			1200	1200	1200	1200	1200
Supplemental			400	400	400	400	400

4.3 Eskom Fleet

4.3.1 Existing Capacity

The existing capacity of the Eskom fleet totals to 48735 MW. As illustrated in Figure 3 below, coal remains the dominant technology, accounting for approximately 84% of the overall capacity.

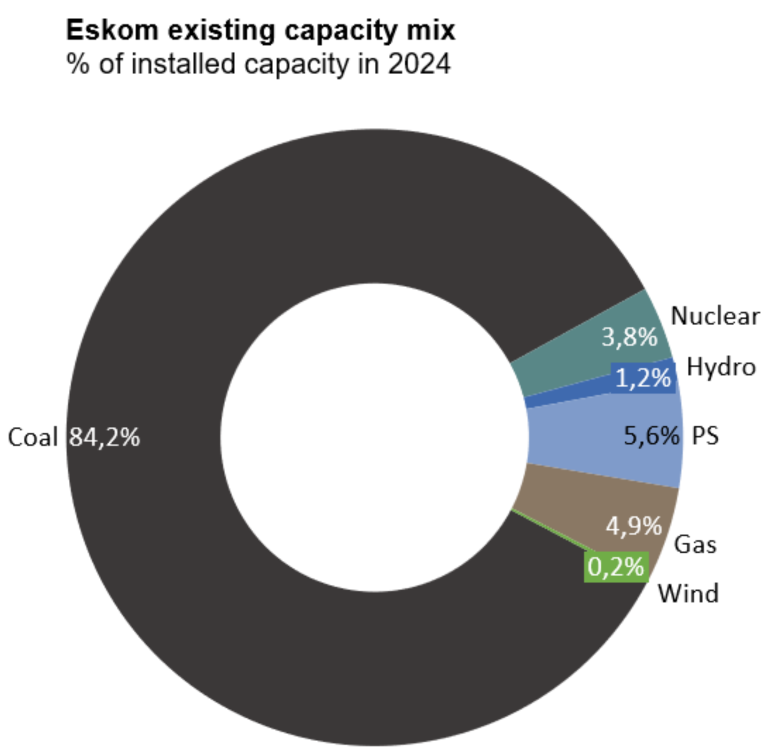

Figure 3: Existing Eskom fleet capacity

Koeberg completed the long-term operation project on unit 1 in December 2023, after which the National Nuclear Regulator (NNR) granted Eskom a license on 15 July 2024 permitting this unit's continuation of operation for another 20 years beyond its initial 40-year lifespan. Koeberg unit 2 which is currently on outage, is utilising this outage for the replacement of steam generators enabling its long-term operation. A request to extend its operations for another 20 years was made to NNR and Eskom awaits the regulator's decision before its current license expires on 09 November 2025, hence there is minimal risk of a delay on unit 2 life extension. Both Koeberg units have been considered in the base installed capacity for the study period.

4.3.2 Eskom Fleet Shutdowns

During the load shedding era in 2023, Eskom reviewed the shutdown plan, taking energy security challenges into account. The outcomes of the review resulted in a position which incorporates continued operations of stations originally due for shutdown from 2023 to 2030.The outcome proposed that Camden, Hendrina, Arnot, Grootvlei and Kriel will continue operating and start shutting down in 2029. This proposal has been used as the generation position for the MTSAO 2024.

The previous MTSAO studies also highlighted compliance to Minimum Emissions Standard (MES) as the risk not only to system adequacy but to the overall security of supply. In terms of the National Environmental Management: Air Quality Act 39 of 2004, all Eskom's coal- and liquid-fuel-fired power stations must meet the MES regulations published in terms of the Act. On 04 November 2021, the Department of Forestry, Fisheries and the Environment (DFFE) made its final decision in respect of Eskom's applications for the postponement of some of the air quality compliance timelines set in air quality legislation for its power stations. In the decision, the stance that DFFE took was for Eskom to strictly comply with prescribed limits for local pollutants.

Eskom submitted an appeal against National Air Quality Officer's decision indicating the risks of this decision on security of supply. In May 2024, the DFFE Minister, following the recommendation of the National Environmental and Consultative Advisory Forum, issued a decision on the Eskom MES appeals in respect of the stack emission limits which coal fired stations must comply with. The Minister ruled that stations shutting down by 2030 (Grootvlei, Arnot, Camden, Hendrina and Kriel) are exempted from the MES requirements, allowing them to operate at existing plant emission limits until 31 March 2030. The stations cannot operate beyond this date, and Eskom must submit detailed decommissioning plans within 12 months. Eskom is preparing the plans as required. For all other coal stations, the Minister made an interim decision requiring the submission of exemption applications motivating for MES indulgence in terms of compliance time frames and emission limits by 10 December 2024. Eskom is preparing the necessary exemption applications for submission to the Minister.

Eskom fleet that is expected to reach the end of its operational lifespan within the study horizon and is scheduled for shutdown is shown in Figure 4.

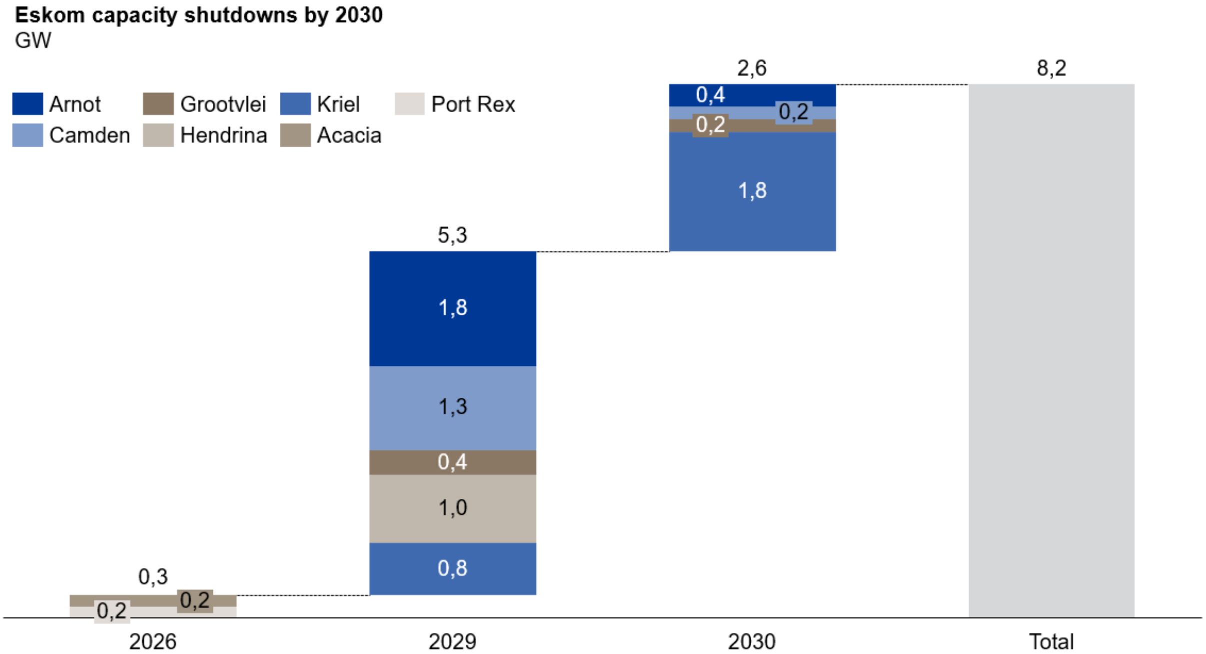

Figure 4: Capacity shutdown between 2024 and 2030

Eskom's coal fleet capacity will decrease by 5.3 GW in 2029, due to the shutdown of units at Arnot, Camden, Grootvlei, Hendrina, and Kriel power stations, with the remaining capacity of 2.6 GW from these stations scheduled to be shutdown by March 2030. Additionally, Eskom's OCGT fleet will experience a reduction of 372 MW in 2026 due to the shutdown of the Acacia and Port Rex plants.

4.3.3 Eskom Coal New Build

Eskom's Kusile unit 5 achieved commercial operation in July 2024, contributing an additional 800 MW to the national grid. The final unit at Kusile, unit 6, is scheduled to achieve commercial operation by July 2025, adding a further 800 MW of stable generation capacity to the grid. Medupi unit 4, which has been out of service for an extended period due to a generator explosion, is expected to return to service by the end of March 2025.

4.3.4 Plant Performance

Eskom plant performance has been on the decline in the past years which resulted in load shedding. However, Eskom's focus on reducing load shedding by improving the performance of the fleet through effective implementation of the Energy Availability Factor (EAF) recovery programme has resulted in a turnaround and end to load shedding. The country has been free of load shedding for more than 7 months and has gone through winter without loadshedding, a performance that should be applauded. This turnaround was delivered through an intensified focus on recovering performance at the worst-performing stations, while sustaining performance at the stations that have shown reliable performance. The EAF for September year to date financial year in 2024 was 63% versus 55% in 2023, an 8% improvement. Eskom's recovery of the operational performance is focusing on improving EAF to 70% in March 2025 in accordance with the Generation Recovery Plan.

The MTSAO has considered two EAF scenarios. The first scenario is a moderately optimistic scenario called high EAF which represents a moderately optimistic recovery of EAF levels and is based on partial recovery initiatives. This scenario reflects an annual average EAF of 63% over the study period. The second scenario is a low EAF scenario which represents a position where recovery initiatives are unsuccessful in turning around the historical EAF trend. This scenario is aligned with the draft IRP 2023 and reflects an annual average EAF of 50% over the study period. The two EAF scenarios are illustrated graphically in Figure 5.

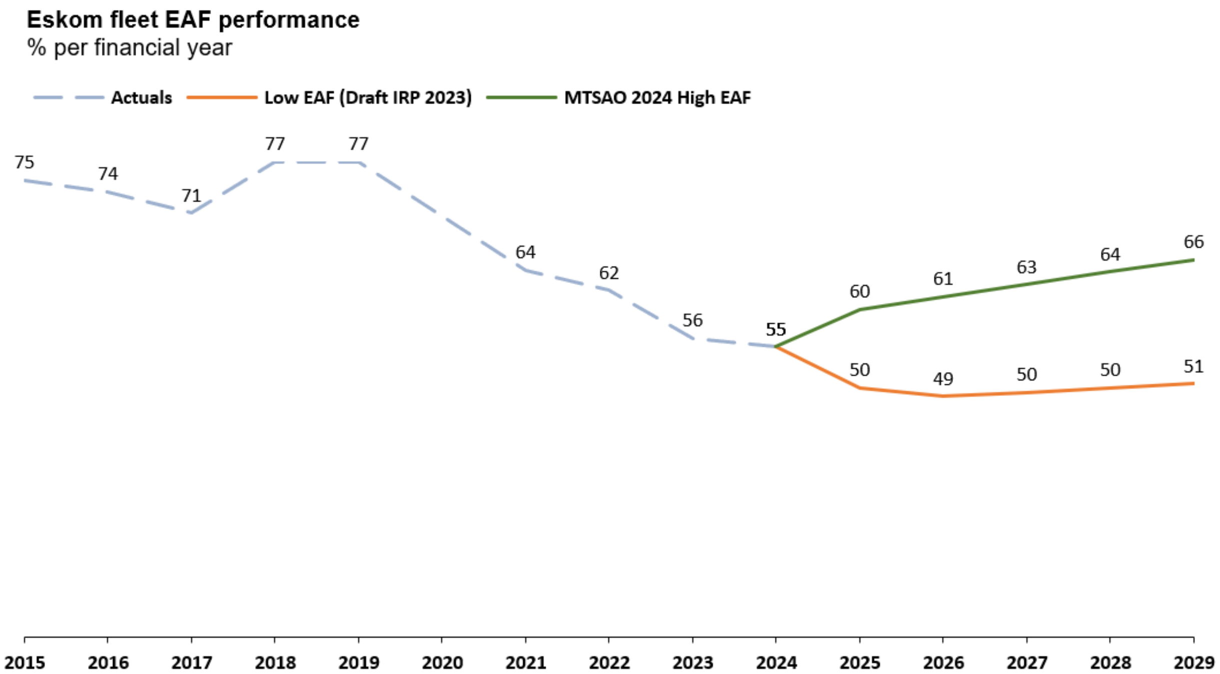

Figure 5: Historical and forecasted EAF performance for Eskom's existing fleet.

4.4 New Generation Capacity

4.4.1 Eskom Renewable Energy Projects

As part of the company's commitment to increase its share of renewable energy generation and to repurpose some of the old coal power stations, Eskom has a pipeline of projects that are under consideration and development. These projects are a combination of Wind, Solar PV and battery energy storage system (BESS). The projects that are anticipated to reach commercial operation dates within the MTSAO study horizon amount to 2183 MW and are shown in Figure 6 below.

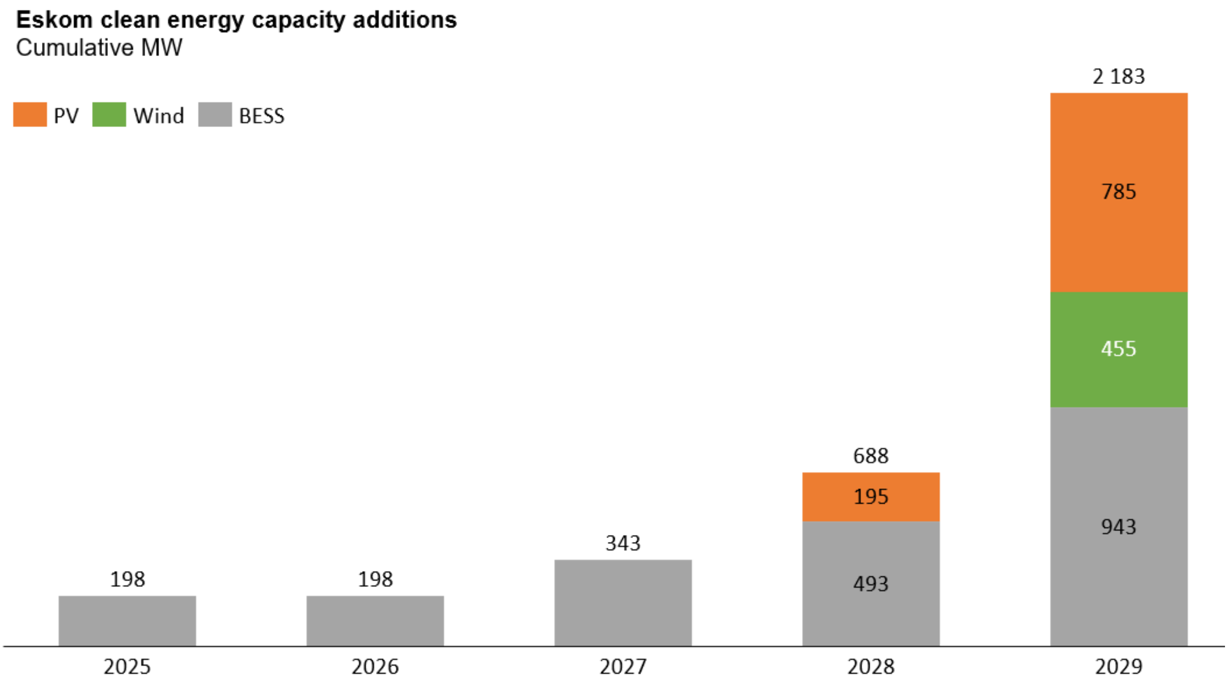

Figure 6: Eskom's new RE projects

The projects from 2025 to 2027 are the Eskom BESS Phase 1 (197.5 MW) and Phase 2 (145.5 MW). A further increase of 345 MW (195 PV and 150 MW BESS) in 2028 are the projects that are currently in execution stage, while the remaining projects that result in the total being 2183 MW are still under consideration and are anticipated to reach commercial operation in 2029.

4.4.2 Renewable Independent Power Producer Programme

The MTSAO study assumes a cumulative capacity from the Renewable Energy Independent Power Producer Programme (REIPPP) up to Bid Window 7 and the committed Risk Mitigation Independent Power Producer Procurement Programme (RMIPPPP) as shown in Figure 7 below.

The existing capacity in commercial operation amounts to 6431 MW and consists of 3343 MW Wind, 2287 MW PV, 600 MW CSP, 150 MW RMIPPP, 25 MW from Biomass, 18 MW from Hydro and 8 MW from Landfills.

Planned capacity amounts to 6797 MW and consists of 1159 MW Bid Window 5, 360 MW Bid Window 6, 5000 MW Bid Window 7 and 278 MW RMIPPP. Pertaining to the planned capacity, Bid Window 5 projects are currently being constructed and are expected to reach commercial operation by 2025. Bid Window 6 projects reached commercial close on the 30th April 2024 and are also expected to be operational by 2025. RMIPPP projects are similarly expected to become operational by 2025. The Request for Proposals (RFP) for Bid Window 7 has closed, and the preferred bidders are anticipated to be announced in November 2024, with commercial operation projected by 2027.

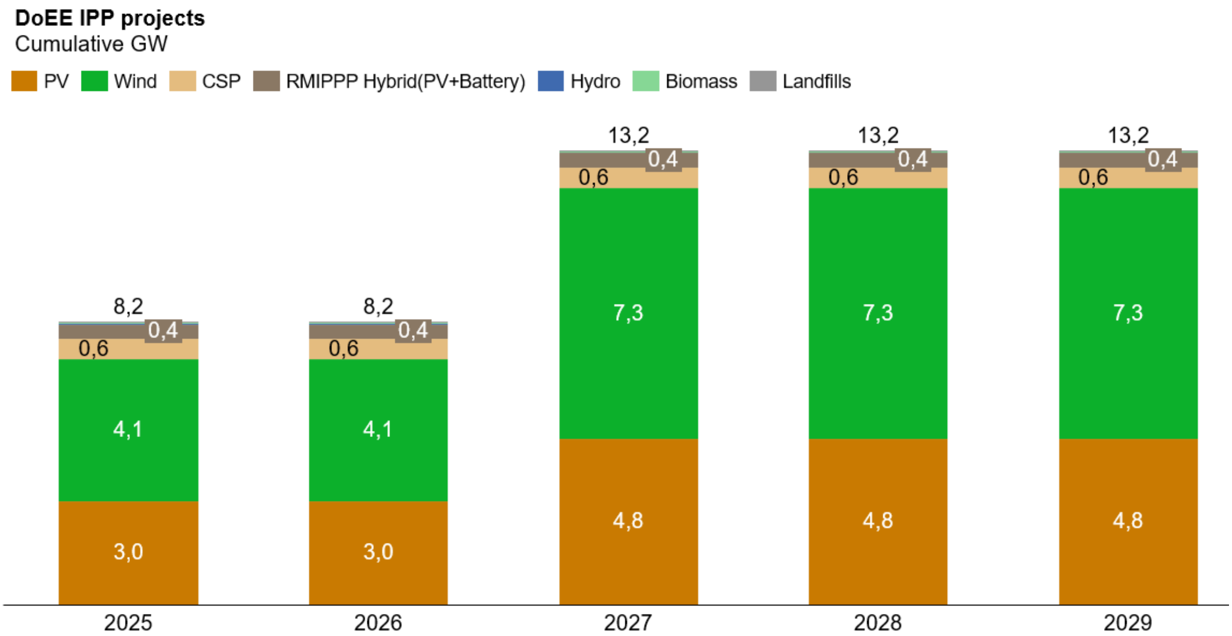

Figure 7: Renewables capacity from Independent Power Producers

4.4.3 IPP Battery Energy Storage System

The MTSAO study assumed cumulative battery energy storage capacity from the IRP up to Bid Window 3. The cumulative capacity from all three bid windows is illustrated graphically in Figure 8.

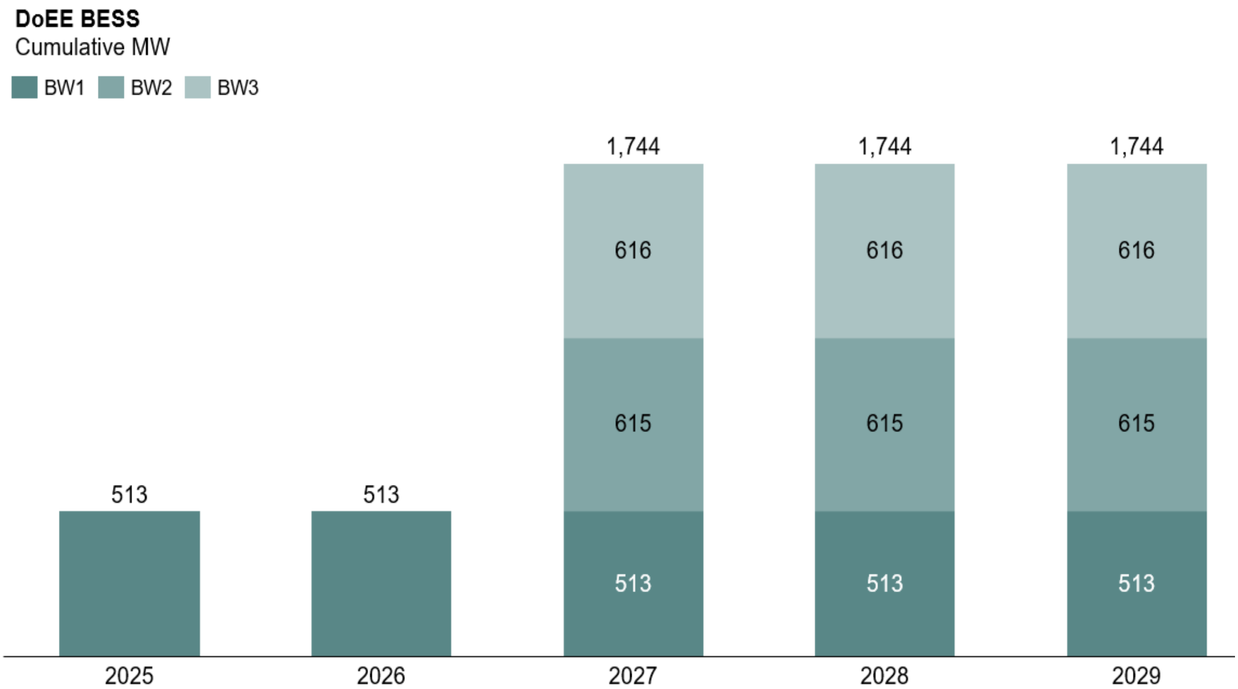

Figure 8: Batteries from Independent Power Producers

Bid Window 1, 2 and 3 amount to 513,615 and 616 MW respectively. Two projects under Bid Window 1, totalling 182 MW, will be signed in October 2024, with the remaining projects under this window expected to be signed by November 2024. These projects are forecasted to reach commercial operation by 2025. For Bid Window 2, bid submissions closed in August 2024, and the preferred bidders are expected to be announced in November 2024, with commercial operation expected by 2027. Bid Window 3, which had its RFP issued in March 2024, will close bid submissions at the end of October 2024, and commercial operation for these projects is also expected by 2027.

4.4.4 IPP Gas

The study also considered the 3000 MW gas allocation from the IRP 2019 as a dispatchable capacity, with commercial operation anticipated by 2029, which falls within the study horizon. The project will be implemented in two phases, with phase one being a 2000 MW and phase 2 being 1000 MW. The preferred bidder announcement for phase one is expected by March 2025, with RFP for phase two scheduled to be issued in the same month.

4.4.5 Power Generation Initiatives by the Private Sector

Several utility-scale private renewable energy power plants are in the planning stages of connecting to the national grid in South Africa. These projects aim to either supply power for self-consumption, helping customers reduce their energy costs, or facilitate wheeling agreements, where energy is transmitted through the grid to private customers. While there are numerous projects in the pipeline, the MTSAO only considered projects that are in the Budget Quote (BQ) stage and beyond, as these are the projects that have reached a more advanced level of planning and commitment and have a high integration potential to the grid. These projects amount to 8681 MW and consist of 4768 MW PV, 3895 MW Wind and 18 MW of Biogas. The cumulative capacity of these projects within the study period is shown in Figure 9.

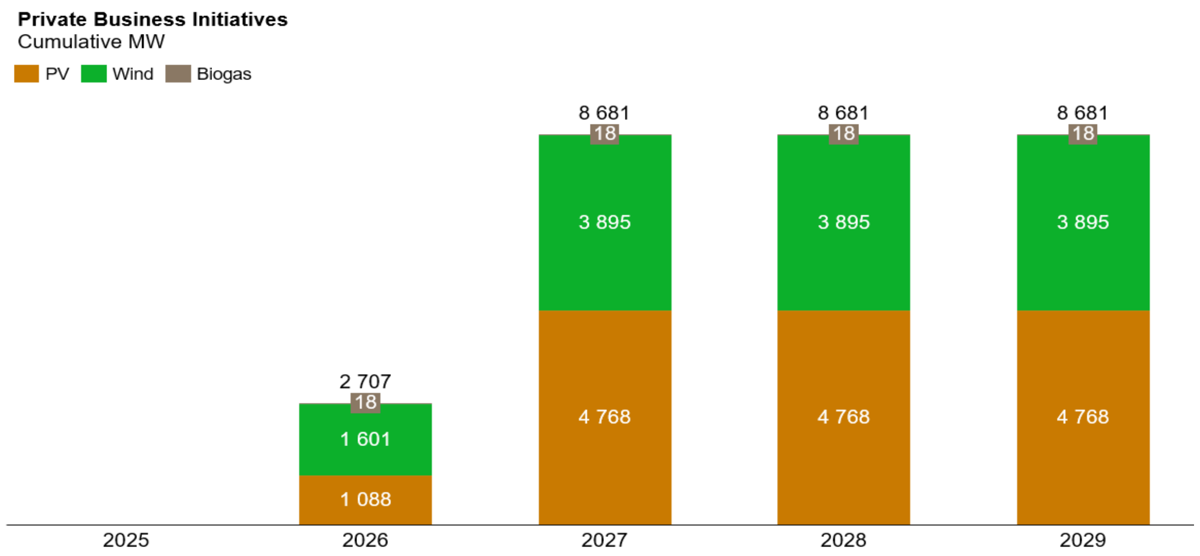

Figure 9: Private Sector Generation Initiatives

A total capacity of 2707 MW (1088 PV, 1601 Wind and 18 Biogas) is expected to reach commercial operation in 2026, as these projects have fulfilled all BQ requirements and are currently finalising their designs, after which they will proceed to the construction phase. The remaining projects which result in a cumulative capacity of 8681 MW are expected to reach commercial operation by 2027, as these projects are still in BQ stage and have not yet met all the requirements necessary to advance beyond this stage.

4.4.6 Small Scale Embedded Generation

The lack of centralised validated data remains a challenge in determining the full extent of Small-Scale Embedded Generation (SSEG) installations. The System Operator data indicates that the embedded generation could be as high as 6141 MW currently (System Operator Weekly System Status Week 42 of 2024). The MTSAO has considered two projections for the study horizon namely low and high penetration levels of SSEGs. The low penetration level is based on the statistical projections using recent low penetration levels after the end of loadshedding and corresponds to an average growth rate of 322 MW per annum. The high penetration level is based on GreenCape's projection of 900 MW per annum within the study horizon. Consequently, the low and high penetration scenarios are expected to result in an additional 1612 MW and 4500 MW of SSEGs being added to the grid over the study period.

4.5 Other Non-Eskom Generators licensed by NERSA

The MTSAO also accounted for non-Eskom licensed capacity connected to the grid (excluding Avon, Dedisa, and the Cahora Bassa hydro import), which contributes approximately 10 TWh, as outlined in Table 2 below. Due to the unavailability of detailed data for non-Eskom power plants, the MTSAO assumed typical plant performance based on facilities of similar type, size, and age. In addition, similar energy production based on historical performance has been assumed for the future.

Table 2: Non-Eskom capacity and energy

Technology Name	Capacity (MW)	Energy (GWh)
Coal	1328	5460
Gas	582	2950
Cogeneration	198	1210
Pumped Storage	180	210
Hydro	31	140
PV	36	70
Wind	7	10
Biogas	17	30
Biomass	8	70
Total	**2387**	**10150**

Furthermore, additional capacity within the MTSAO includes the 1005 MW from the DoEE Independent Power Producer (IPP) peaking plants namely Dedisa and Avon, as well as the 1150 MW from the Cahora Bassa import.

5. NEW GENERATION CAPACITY CATEGORISATION

Given the inherent uncertainty surrounding some of the projects considered for the MTSAO 2024, the study has grouped the projects into distinct categories to represent various potential outcomes for future capacity development. These categories are committed new capacity, all new capacity, and risk-adjusted new capacity, each reflecting different levels of project readiness and likelihood of success.

5.1 Committed New Capacity

Committed capacity consist of projects that have reached financial close, and are either in construction or in the process of finalising their designs to enter the execution stage. The capacity that falls under this category is shown in Figure 10 below. The study has included this capacity as part of the base, and it reflects a growth from 2882 MW in 2025 to 6655 MW by 2029. This capacity is 4182 MW higher than the new capacity that was included in the MTSAO 2023 base. The reason for this significant increase is that many of these projects, which previously had uncertain commercial operation dates in the MTSAO 2023, now have much greater certainty due to their advanced stages of development.

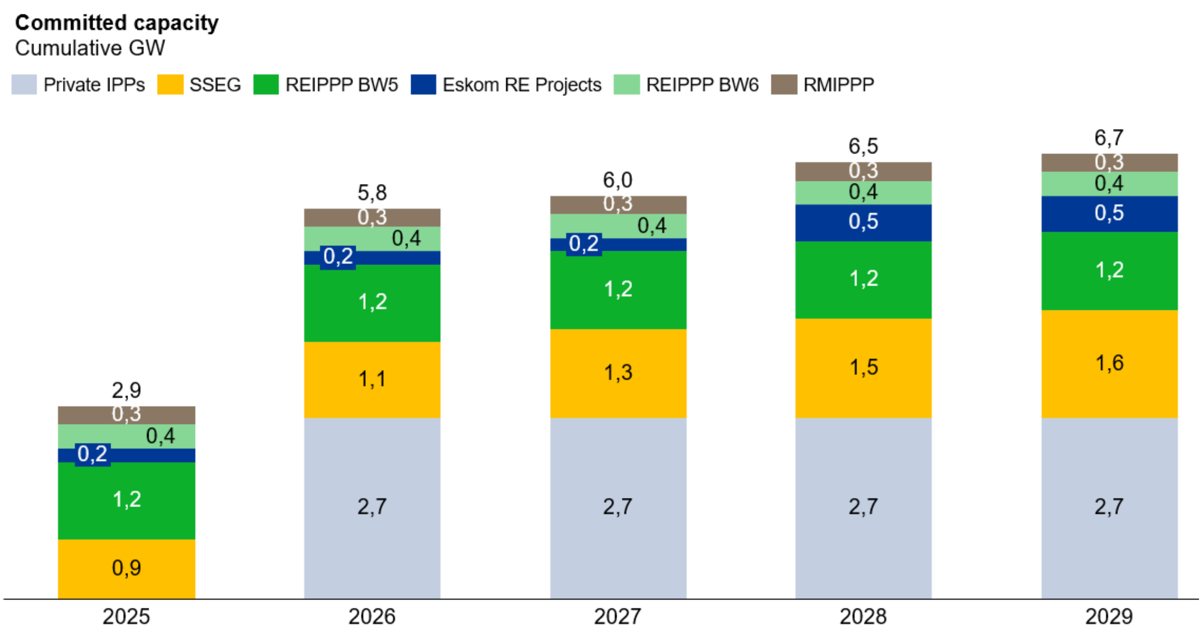

Figure 10: Committed New Capacity

5.2 All New Capacity

All new capacity consists of all the projects from various stages of development that are in the pipeline within the 5-year study period. This category captures a broader range of initiatives, including those in earlier phases such as feasibility and planning. The capacity under this category grows from 2895 MW in 2025 to 26905 MW in 2029. Different initiatives that are anticipated to contribute to this category are shown in Figure 11 below.

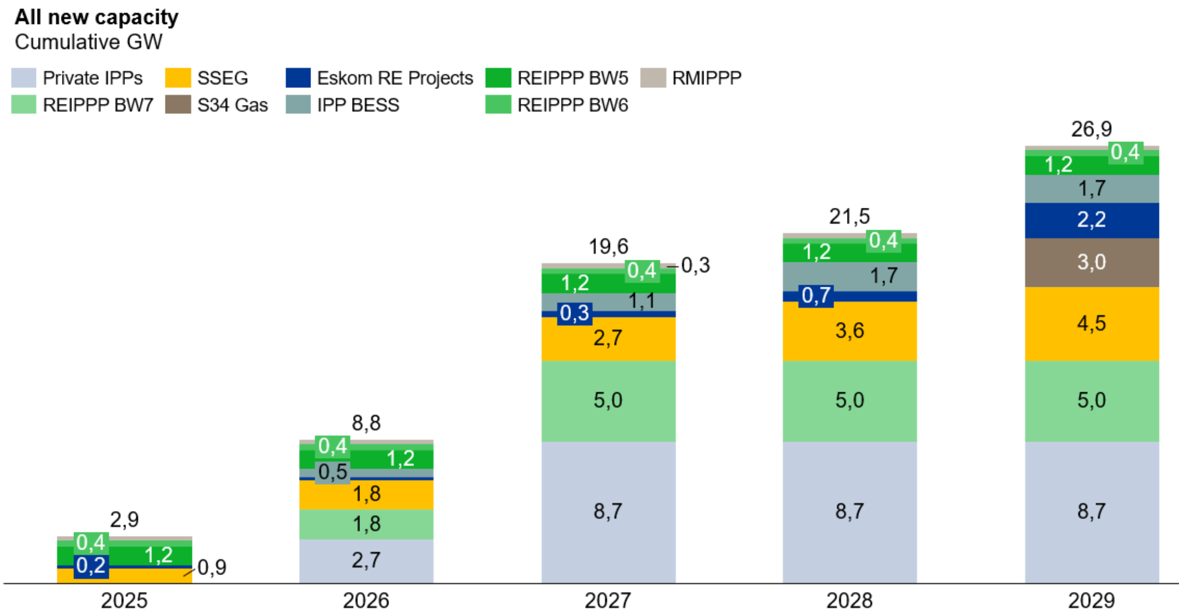

Figure 11: All New Capacity

5.3 Risk Adjusted New Capacity

Risk-adjusted capacity represents a selection of projects based on sensitivity analysis. Unlike the broader all-new capacity category, which includes projects across various development stages, the risk-adjusted category narrows the focus to those projects with a stronger probability of achieving commercial operation, despite their current phase in the development pipeline. The category differs from the committed capacity in that it includes the PV projects from BW7, Eskom BESS phase 2 and BESS BW1. The capacity under this category grows from 2882 MW in 2025 to 9113 MW in 2029 and the projects which fall under this category are shown in Figure 12 below.

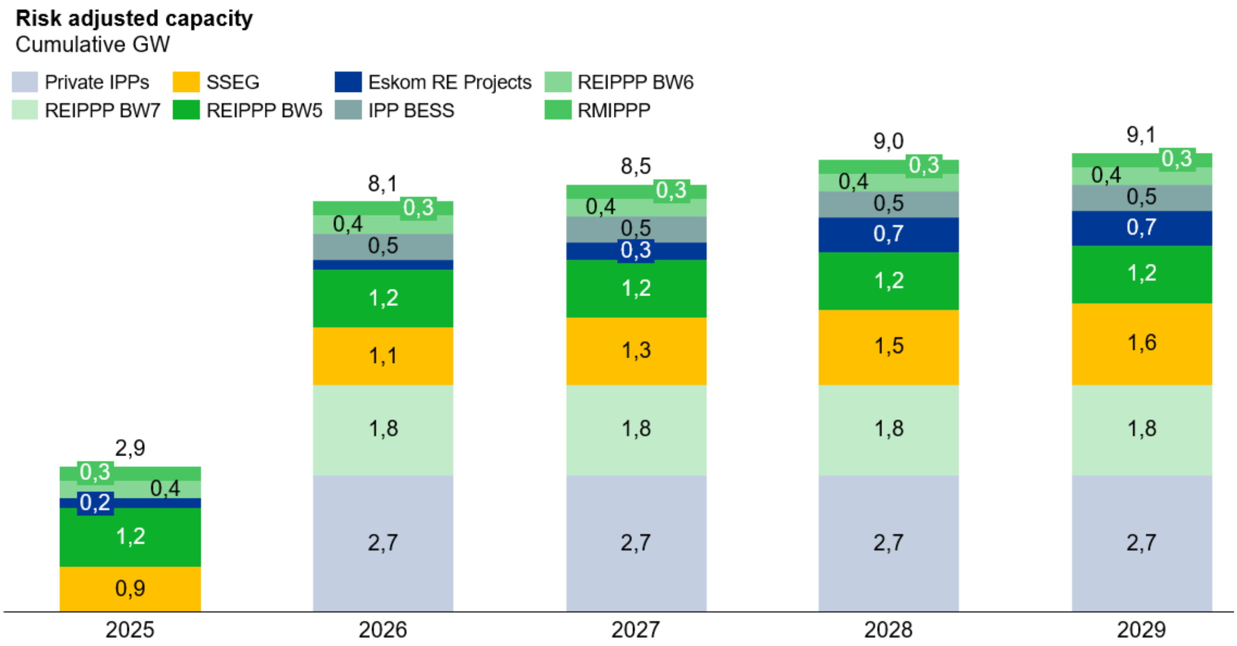

Figure 12: Risk-adjusted New Capacity

6. STUDY CASES

The studied scenarios were selected based on the three most probable outcomes related to future capacity development, as outlined in Section 5. The MTSAO study considered 5 scenarios, which are presented in Table 3 below.

Table 3: MTSAO 2024 scenarios

Description	Base Case	All Levers Scenario	Risk-Adjusted New Capacity Scenario	High Demand Scenario	Low EAF Scenario
High EAF	X	X	X	X	
Low EAF					X
Moderate Demand	X	X	X		X
High Demand				X	
Committed New Capacity	X			X	X
All New Capacity		X			
Risk-adjusted New Capacity			X		

The base case, which assumes a high EAF and moderate demand, form the basis of all new capacity scenarios. The all levers scenario differ from the base case in that it considers all new capacity in the pipeline, all new projects are included regardless of their stage of development. The risk-adjusted scenario focuses only on projects with a high likelihood of success. The final two scenarios namely high demand and low EAF consider committed capacity only and differ from the base case in that the high demand scenario assumes a higher demand than what is in the base, while the low EAF scenario is based on a declining EAF.

7. RESULTS

7.1 Unserved Energy

The expected unserved energies from different scenarios over the 5-year study horizon are shown in Figure 13.

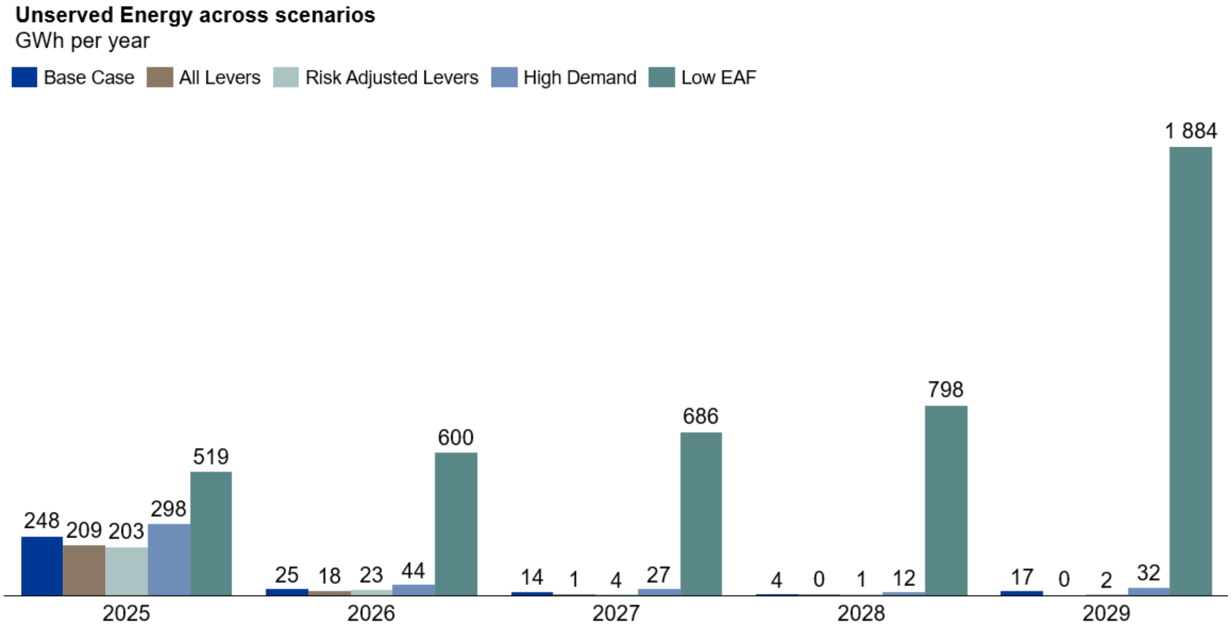

Figure 13: Unserved Energy

The Low EAF scenario results in the highest levels of unserved energy throughout the study period, increasing from 519 GWh in 2025 to 1884 GWh by 2029. This issue is further exacerbated by the scheduled shutdown of coal units in 2029.The high demand scenario is the second most unfavourable scenario for the system, with unserved energy being higher than the adequacy threshold of 20 GWh throughout the study horizon, except in 2028. However, unserved energy under this scenario is within manageable levels. In contrast, the All-Levers scenario emerges as the most effective scenario, with unserved energy dropping below 20 GWh from 2026 onward. Base Case and Risk-Adjusted scenarios also show significant improvement, with unserved energy levels falling below the adequacy threshold from 2027.

7.2 OCGT Utilisation

The expected OCGT utilisation from different scenarios over the 5-year study horizon is shown in Figure 14.

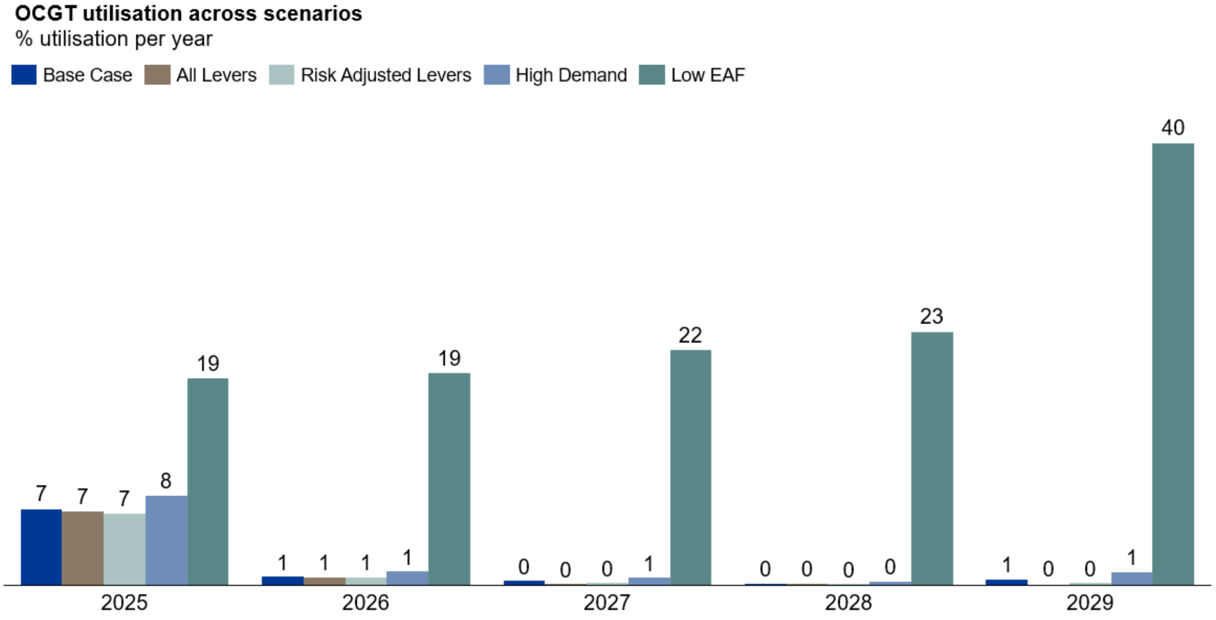

Figure 14: OCGT Utilisation

The Low EAF scenario stands out as the worst-case scenario, even under this metric, with its OCGT capacity factor increasing from 19% in 2025 to 40% by 2029. The scheduled shutdown of coal units in 2029 further exacerbates the capacity factor issue within this scenario. All the other scenarios marginally exceed the 6% adequacy threshold only in 2025 and are below this threshold from 2026 until the end of the study period.

7.3 System Adequacy Evaluation

The system adequacy evaluation for the MTSAO study is presented in Table 4. It includes the analysis of Unserved Energy (EU), OCGT Capacity Factor (OCGT), and System Adequacy Outlook (AO). The table uses a color-coded system to represent different levels of adequacy. Green indicates no violation of adequacy metrics, orange represents minor violations of one or more metrics, which can be managed by the available levers within the System Operator, and red signals a critical situation where one or more adequacy metrics are significantly exceeded, indicating an unfavourable system.

Table 4: MTSAO system adequacy evaluation

	Base Case			All Lever			Risk-Adjusted			High Demand			Low EAF		
	UE	OCGT	AO	UE	OCGT	AO	UE	OCGT	AO	UE	OCGT	AO	UE	OCGT	AO
2025	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Red	Red	Red
2026	Orange	Green	Orange	Green	Green	Green	Orange	Green	Orange	Orange	Green	Orange	Red	Red	Red
2027	Green	Green	Green	Green	Green	Green	Green	Green	Green	Orange	Green	Orange	Red	Red	Red
2028	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red
2029	Green	Green	Green	Green	Green	Green	Green	Green	Green	Orange	Green	Orange	Red	Red	Red

The results indicate no significant concerns for the base case, all levers, risk-adjusted, and high demand scenarios. Although there are some violations of adequacy metrics in these scenarios, they remain within manageable limits. In contrast, the low EAF scenario presents major challenges, where the system is inadequate on both metrics, and the severity of the inadequacy worsens as demand increases.

7.4 Excess Energy

7.4.1 Scenario-Based Analysis

The expected excess energy from different scenarios over the 5-year study horizon are shown in Figure 15 below.

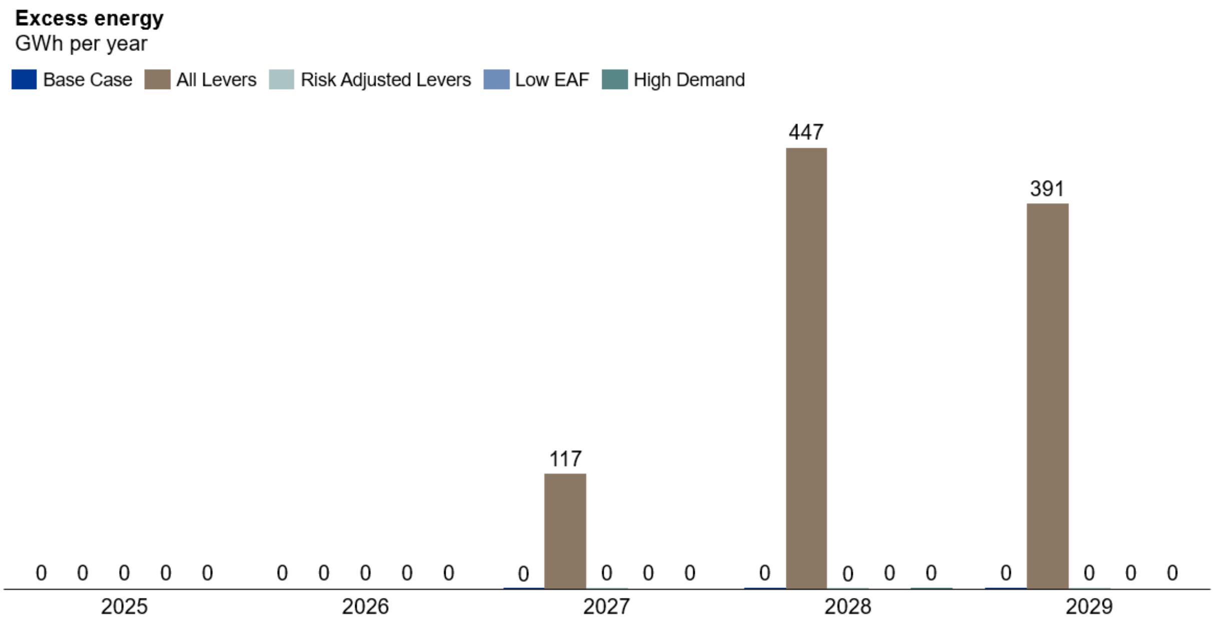

Figure 15: Excess Energy

The MTSAO results indicate that the system will experience generation in excess of the load with the all-lever scenario. This surplus is attributed to operational constraints associated with certain generators, such as coal plants with minimum stable generation requirements and non-dispatchable renewable energy sources As more generation is added to the system, the level of excess energy increases. Although the scheduled shutdown of coal units in 2029 is expected to reduce excess energy, the impact is minimal due to the simultaneous addition of new renewable energy generators, which offsets the positive effects that coal shutdown would have had on the excess energy. No excess energy is reported in other scenarios.

The applications for grid access for generation from private sector changes every month and the data as at October 2024 indicates 13901 MW, a 5220 MW increase from the initial estimate of 8681 MW used in the all levers scenario. A sensitivity on all levers scenario was done to see the impact of this capacity increase on the system and the result show similar pattern to the results of all levers scenario with regards to excess energy. The excess energy is however significantly higher with the additional 5220 MW integrated on the system. Specifically, the projected excess energy levels are 1083 GWh in 2027, 3171 GWh in 2028 and 2588 GWh in 2029.

7.4.2 Daily Renewable Energy Analysis

Due to the high penetration levels of renewable energy sources as shown in the All-lever scenario, a comprehensive evaluation of low and high renewable energy days was conducted to analyse the impact that these RE sources have on the generation system. The results of this analysis are discussed below.

I. A typical high renewables day indicates the following:
   - Coal power plant contribution is 15% less during high renewable energy days compared to the low renewable energy days. The days with high excess energy indicate coal power plants to be generating at their minimum stable levels.
   - No unserved energy is observed during high renewable energy days. However, this is when the excess energy tends to be dominant, and it is observed during peak generation period of PV plants which is at midday.
   - The levels of excess energy are also dependent on the demand and tend to be significantly higher during low demand days. A combination of high renewable energy day and low demand day is expected to result in increased excess energy

II. A typical low renewables day indicates the following:
   - No excess or unserved energy is expected on the low renewable energy days.

8. CONCLUSIONS AND RECOMMENDATIONS

MTSAO 2024 has assessed the adequacy of the SA power system for the 2025 to 2029 calendar years. Several assumptions as described in section 4 of this report were made to complete the study. Results showed the following:

- The previous MTSAO studies indicated that improving EAF is the single most effective lever to improve the system adequacy. This has been demonstrated in the previous 7 months of no load shedding due to improved generation performance. Though MTSAO 2024 used a moderately improving EAF, the system remains adequate even at that EAF. The Eskom Generation Recovery Initiatives aimed at improving EAF to levels above 70%, will further enable the economic growth for the country.
- The declining EAF scenario emphasise the importance of maintaining good plant performance as the drop in EAF will take the country back to the constrained system and possible load shedding.
- The all-lever scenario presents a new challenge in the form of excess energy on the system. However, this scenario is predominantly dependent on projects that are still in the feasibility stages, and this introduces high uncertainty pertaining to its full materialisation.
- The base case, risk adjusted, and high demand scenarios marginally exceed the adequacy metrics within manageable levels, suggesting that the system is resilient enough to absorb fluctuations and align with the adequacy requirements that are critical for a stable and reliable system.
- The study thus concludes that the system is adequate and will remain adequate if the high EAF levels are maintained.

Based on the conclusions of the report, the study recommends the following:

- Continued focus on the Maintenance Recovery Plan to improve performance is recommended to ensure sustained high EAF levels.
- The MTSAO 2024 assumes that Kusile unit 06 will reach commercial operation and Medupi unit 04 will return to service during the study period. These are two big base load units with a big impact on the system, their delays will negatively impact the system, and hence it is important for system adequacy that they are not delayed.
- The impact of additional renewable energy capacity on the grid needs to be studied and understood, as intermittency and variability of these technologies introduce supply and demand balancing challenges on the system. As the penetration levels of these technologies increase, the complexities associated with supply and demand balancing also increase. Understanding the impact that these additional renewables have on the system will enable SO to put measures in place that ensures the system remains resilient and stable.

9. APPENDIX A: SYSTEM OPERATOR STATISTICS

This section monitors and reports actual system reliability indices that are affected by the adequacy of a power system. The data reports trends from January 2017 to 2024 year to date as at end of September 2024, with data available for retrieval from the National Transmission Company of South Africa Data Portal (2024).

9.1 Performance of Reserves

Table 5 shows 2023 frequency incidents outside the 49.7 < f < 50.3 frequency band. Ancillary services (reserves) play a crucial role in ensuring that the system is within the frequency band and are also necessary to support renewable energy integration, particularly the integration of intermittent resources. However, actual reserve provision is underperforming, indicating a power system critically short of operating reserves, which poses a risk to the system's ability to arrest frequency deviations.

Table 5: 2023 Frequency incidents

2023	49.5 < f < 49.7	f < 49.5	f > 50.3	50.5 > f > 50.4	f > 50.5
Jan	153	5	52	9	2
Feb	170	8	68	4	3
Mar	145	1	37	1	0
Apr	275	4	86	0	0
May	257	9	201	21	4
Jun	57	4	73	2	0
Jul	123	5	57	4	0
Aug	91	4	40	2	0
Sep	145	12	31	0	0
Oct	71	1	15	1	1
Nov	197	4	35	1	0
Dec	108	4	40	6	0

9.2 OCGT Utilisation

The System Operator's dispatchable gas peaking plants include Eskom's Ankerlig (1327MW) and Gourikwa (740MW), as well as DOEE OCGTs at Dedisa (335MW) and Avon (670MW). Figure 17 illustrates the generation output from these resources over the past years. Usage of OCGTs to balance supply and demand has increased significantly between 2019 and 2023. However, the year-to-date utilisation in 2024 is notably lower compared to 2023 and is unlikely to increase substantially in the remaining three months of 2024.

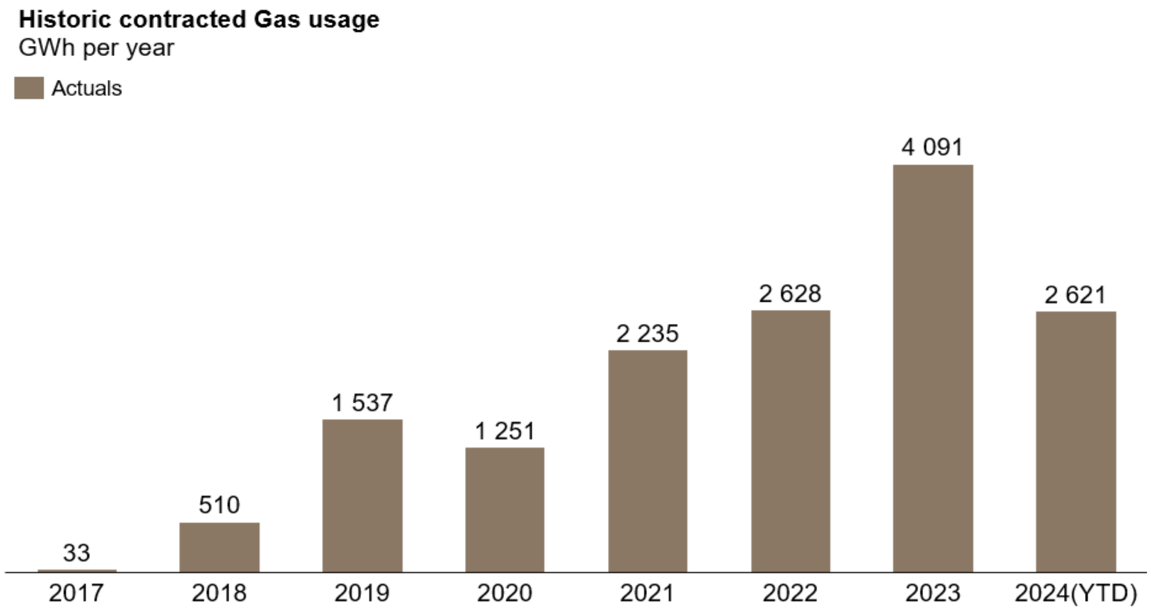

Figure 16: Actual OCGT utilisation 2017 to 2024 YTD

9.3 Unserved Energy

To maintain a stable power system amidst supply shortages, the System Operator implements load shedding and/or demand curtailment. Figure 17 shows historical recorded energy not supplied as 2404 GWh for the current year to date. The values include load shedding and load curtailment but exclude interruption of supply (IOS). IOS refers to all contracted and mandatory demand reductions to maintain system frequency and security of supply within acceptable bands.

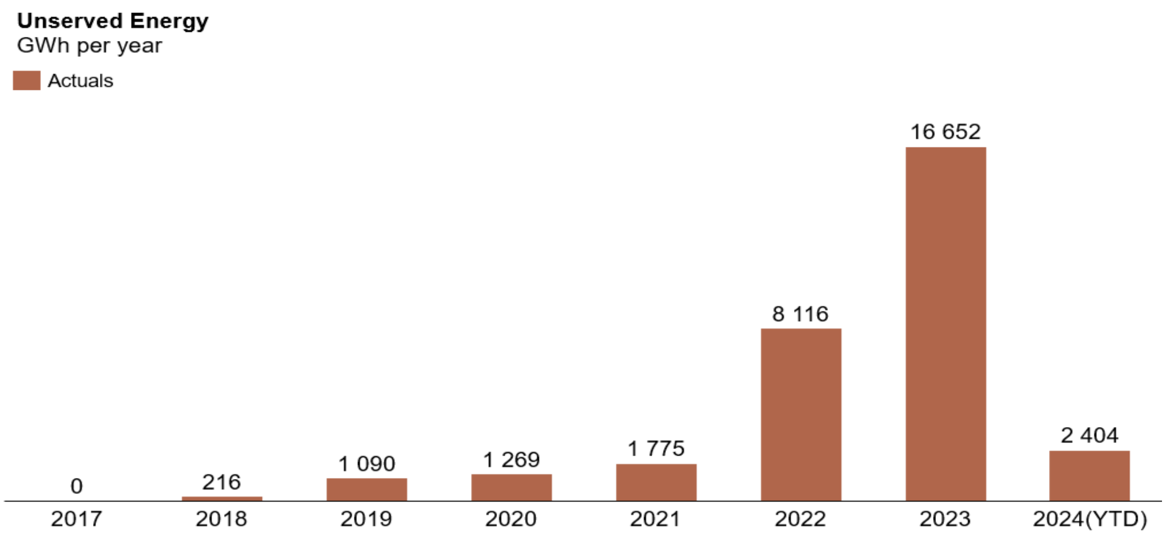

Figure 17: System Operator instructed load shedding for the calendar year 2017 to 2024 YTD

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