Medium-Term System Adequacy Outlook 2024-2028

Generation System Adequacy for the Republic of South Africa

30 October 2023

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 five years. The objective of this publication is 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 taking 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 2023, unless otherwise indicated.

The MTSAO does not optimise in terms of the type and timing of capacity required to close the supply gap, as is the case when developing the Integrated Resource Plan (IRP). Furthermore, the MTSAO does not assess the adequacy of the grid needed to transmit and distribute electricity. Therefore, the detail 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 is not assessed.

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ABBREVIATIONS

Term/Abbreviation	Definition
AAGR	Annual average growth rate
BWs	Bid windows
CSP	Concentrated solar power
DFFE	Department of Forestry, Fisheries, and the Environment
DMRE	Department of Mineral Resources and Energy
DPE	Department of Public Enterprises
EAF	Energy availability factor
f	Frequency
GCCA	Generation Connection Capacity Assessment
GDP	Gross domestic product
GVA	Gross value added
GW	Gigawatt
GWh	Gigawatt-hour
Gx	Generation
IOS	Interruption of supply
IPP	Independent power producer
IRP	Integrated Resource Plan
MES	Minimum emission standards
MTSAO	Medium-Term System Adequacy Outlook
MW	Megawatt
NECA	National Environmental and Consultative Advisory
NECOM	National Energy Crisis Committee
NERSA	National Energy Regulator of South Africa
NNR	National Nuclear Regulator
OCGT	Open-cycle gas turbine
OCLF	Other capacity loss factor
PCLF	Planned capacity loss factor
PGMs	Platinum group metals
PV	Photovoltaic
REIPPP	Renewable Energy Independent Power Procurement Programme
RMIPPPP	Risk Mitigation Independent Power Producer Procurement Programme
RSA	Republic of South Africa
SAGC	South African Grid Code
SO	System Operator
SSEG	Small-scale embedded generation
TWh	Terawatt-hour
UCLF	Unplanned capacity loss factor

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 five calendar years within acceptable levels of reliability using predefined adequacy metrics. The current MTSAO for the period 2024 to 2028 calendar years, hereinafter referred to as the MTSAO 2023, considers the following key assumptions:

Demand assumptions:

i. The moderate demand forecast has an annual average growth rate of 0.64%.

Plant performance assumptions:

i. Low EAF: this scenario depicts a declining performance averaging 50% EAF over the study period.
ii. High EAF: this scenario depicts an EAF that improves to 66% in 2024 and climbs by 0.5% annually to 68% by the end of the study period.

Four reference scenarios are studied using the two EAF trajectories and the moderate demand forecast. The study, furthermore, assesses the impact of new generation capacity from the NECOM initiatives, which include REIPPP Bid Windows 6 and 7, the Risk Mitigation Power Producer Procurement Programme (RMIPPPP), IRP gas, land lease, and utility-scale and private-sector embedded generation as levers. An additional lever considers continuation of operation for all Eskom generation units that are currently operational for the MTSAO 2023 study horizon.

In terms of risks, this study considers the current constraints on the national transmission grid and how these will affect possible new build generation capacity over the MTSAO 2023 period.

The results of the MTSAO 2023 modelling show the following:

- In terms of unserved energy, no scenario achieves the system adequacy metric of 20 GWh in all years of the MTSAO period.
- The high EAF scenario comes close to adequacy and is deemed “within manageable ranges”.
- Additionally, the high EAF scenario has OCGT capacity factors of below 6% in all years, which suggests that the observed unserved energy is due to shortfalls at peak usage times.

- While the continuation of operation of older power stations throughout the study period contributes positively to system adequacy, this strategy alone will not resolve high unserved energy over the study period.
- The inclusion of all available new build generation capacity levers also contributes positively and exceeds the benefit of continuation of operation in 2028 with the introduction of dispatchable IRP gas.
- Though combining continuation of operation of older power stations with new build generation capacity levers will also not achieve the desired system adequacy, it does improve system adequacy.
- The study hence recommends a combination of EAF improvement, continued operation of older generation power plants and new build levers, to resolve the energy shortfalls.
- Grid constraints will severely hamper efforts to restore adequacy if left unaddressed as is seen with the exclusion of additional capacity resulting from Bid Window 7 in the grid-constrained scenario. All possible effort should be made to alleviate grid constraints.

2. INTRODUCTION

The Medium-Term System Adequacy Outlook (MTSAO) assesses the ability of the electricity power system to meet demand within predefined adequacy thresholds in the next five calendar years. The current study covers the calendar years 2024 to 2028 and is referred to as the MTSAO 2023.

The MTSAO assessment is meant to identify scenarios and sensitivities when the security of supply faces risks. In particular, the outcomes of the assessment inform:

- stakeholders of the depth and timing of the supply risk, that is, the amount of the demand that could not be served;
- policymakers with foresight to procure sufficient generation resources, that is, when and how much additional energy is required to meet expected demand.

As indicated by the Grid Code, the SO is required to consider:

- potential scenarios for growth in the demand of electricity from consumers. The expected demand includes South Africa's demand plus exports to neighbouring countries;
- potential scenarios for growth and/or decline in generation available to meet the expected demand. These include all the generation resources licensed by the National Energy Regulator of South Africa (NERSA) plus imports from neighbouring countries, demand-side management resources, and distributed generation;
- potential scenarios for new and committed generation projects; and
- any other information that the SO may reasonably deem appropriate.

3. METHODOLOGY

The MTSAO process is presented in Figure 1 and shows how input data consisting of demand forecast and NERSA-licensed generation resources, imports, and demand-side management are assessed hourly to quantify the supply-demand balances or lack thereof over the next five calendar years. The study considers the following stochastic parameters when conducting Monte Carlo simulations: the demand forecast, wind, solar PV, CSP generation production profile, and unplanned power plant outages.

The Monte Carlo simulation method addresses the random nature of these stochastic parameters. The Monte Carlo simulation method computes optimal decisions based on a specified sample size, 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.

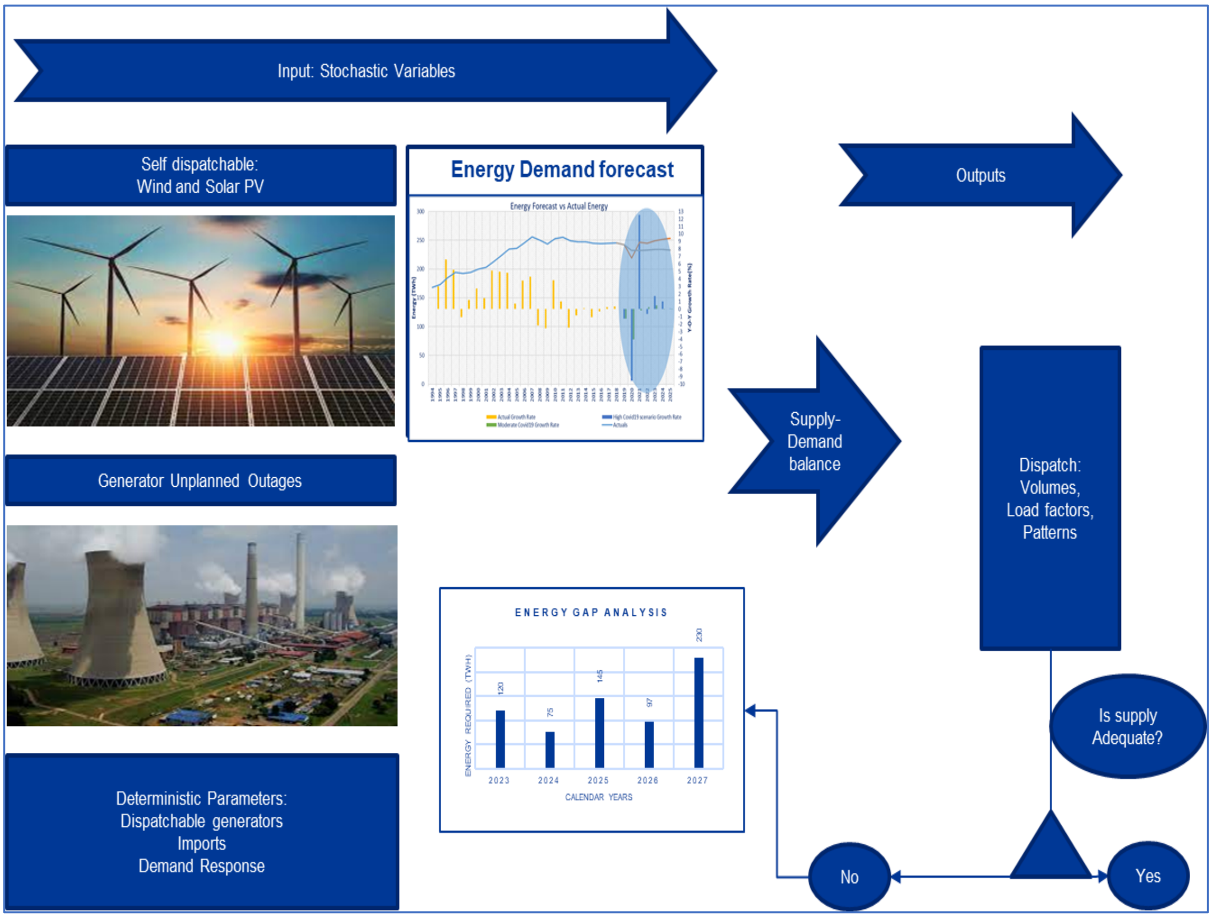


Figure 1: MTSAO methodology

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 thresholds:

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 case of an inadequate system, an energy gap analysis is undertaken to determine the total amount of energy required to restore the electric power system to adequacy.

4. KEY ASSUMPTIONS

This section details key assumptions used in the development of the MTSAO 2023. 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 energy forecast of the country is based on individual forecasts of industry, mining, traction, commercial, residential, and agricultural customers. Econometric regression models are developed using MetrixND software and are used to forecast annual consumption of electricity in each of the economic sectors. Economic and demographic drivers used in the individual sector models include GDP, population, production indices (PGMs, iron ore, gold ore treated, mining production less gold, etc.), household expenditure, the manufacturing production index, and household numbers.

The overall GDP is made up of three economic sectors, namely, the primary, secondary, and tertiary sectors. The contributions of these sectors in the GDP forecast and GVA contributions are as follows:

- Primary sector: expected to grow by an annual average of 1.62%. This sector contributes 8.2% to the total GVA, with the main driver of growth coming from mining.
- Secondary sector: expected to grow by an average of 1.95% annually. This sector contributes 17.7% to the total GVA, with the main contribution coming from the manufacturing sector.
- Tertiary sector: expected to grow by 1.67% on average. This sector contributes 74.1% to the total GVA, with equal contributions from the finance, trade, and transport sectors.

The current energy forecast is uncertain due to a number of risks and unknowns including the ongoing loadshedding, high interest rates putting pressure on the economy, high unemployment rate increasing poverty, political uncertainty and overall economic decline. Hence the moderate energy demand forecast as shown in Figure 2 has been used for the MTSAO 2023 study. It uses the World Economic Outlook IMF GDP with an average of 1.9% for the study period as input into econometric models to calculate the RSA sent out correlated with the economic growth of the country. It assumes energy growth of an average of 0.64% for the MTSAO period. The mining and industry sectors are expected to grow by 0.6% on average. Other sectors such as residential, agricultural, and commercial are also expected to grow at a medium, but steady, pace.

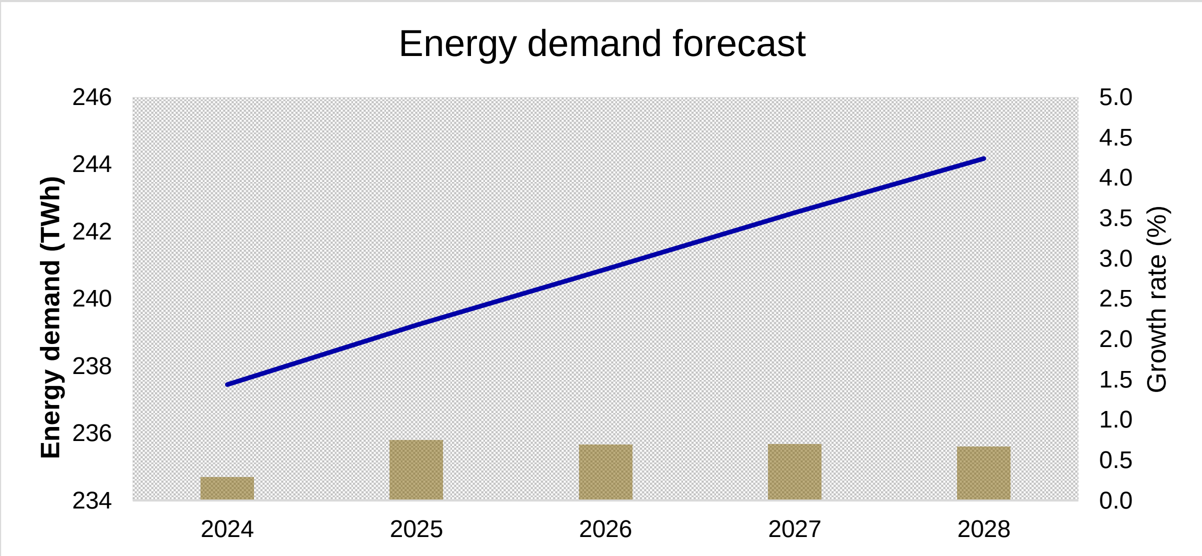


Figure 2: Energy demand forecast

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. An assessment of the magnitude required for each reserve type (these reserves are mutually exclusive) is published annually by the System Operator in the Ancillary Services Technical Requirements report. The MTSAO 2023 includes these reserves and the individual generating unit contributions as well as the demand-side loads contributing to the total. Table 1 below shows the different types of reserves considered in the study as the total minimum provision that must be supplied by contributing generators or demand-side load in the system. The table shows the different types of reserves defined in the SAGC and the Ancillary Services Technical Requirements report 2023/24-2027/28:

i. Instantaneous reserve: this is 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: this is 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: this is 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: this 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: this is generating or demand-side load that can respond in six hours or less to restore operating reserves.

Table 1: Reserve requirement for seasonal peak and off-peak 2023/24 to 2027/28

Reserves	Season		2023/24	2024/25	2025/26	2026/27	2027/28
Instantaneous	Summer/Winter	Peak	650	650	650	650	650
		Off-peak	850	850	850	850	850
Regulating	Summer/Winter	Peak/Off-peak	545	560	575	600	700
Ten-minute	Summer/Winter	Peak	1 005	990	975	950	850
		Off-peak	805	790	775	750	650
Operating	Summer/Winter		2 200	2 200	2 200	2 200	2 200
Emergency			1 400	1 350	1 300	1 250	1 200
Supplemental			200	250	300	350	400

4.3 Eskom capacity

4.3.1 Eskom fleet shutdown

The IRP 2019 indicated a shutdown plan of Eskom power stations, with about 5 400 MW of electricity from coal generation being shut down by Eskom by the year 2022, increasing to 10 500 MW by 2030. Both MTSAO 2022 and 2023 align with the Eskom Journey 2035 strategy shutdown plan, for its reference cases, which in comparison with IRP 2019 already shows a delayed shutdown of older stations in response to the capacity constraints. This shutdown plan results in 6 105 MW of capacity shut down by the end of 2028, which includes:

- 1 400 MW at Arnot;
- 1 480 MW at Camden;

- 570 MW at Grootvlei;
- 1 098 MW at Hendrina;
- 1 215 MW at Kriel;
- 171 MW at Acacia; and
- 171 MW at Port Rex.

Koeberg Power Station would ordinarily reach its 40-year end of design life in 2024 and 2025; however, in line with the IRP 2019, it is envisaged that all nuclear safety/regulatory licences will be extended by an additional 20 years after completion of steam generator replacement project.

4.3.2 Eskom fleet continuation of operation

The shutdown plan as used in the base case and previous MTSAO studies is currently under review by Eskom in light of the current capacity constraints. Hence, the MTSAO 2023 has modelled as a scenario the continuation of operation of all coal-fired stations. The scenario assumes that no coal power plant will be shutdown during the MTSAO 2023 study period. A detailed techno-economic study is currently under way that will provide more planning inputs and optimised shutdown dates in order to balance capacity and economic considerations for the country. At the time of completion of the MTSAO 2023 study the analysis was still ongoing hence the MTSAO 2023 assumes that the performance of these stations will plateau from the year they were scheduled for shutdown, for the period of the study.

Figure 3 shows the difference in Eskom coal fleet between the shutdown plan used in the reference cases and the continuation of operation scenario. The increase in coal capacity between 2024 and 2025 is due to Kusile Units 4 and 5 reaching commercial operation and the return of Medupi Unit 4 which is expected in 2024.

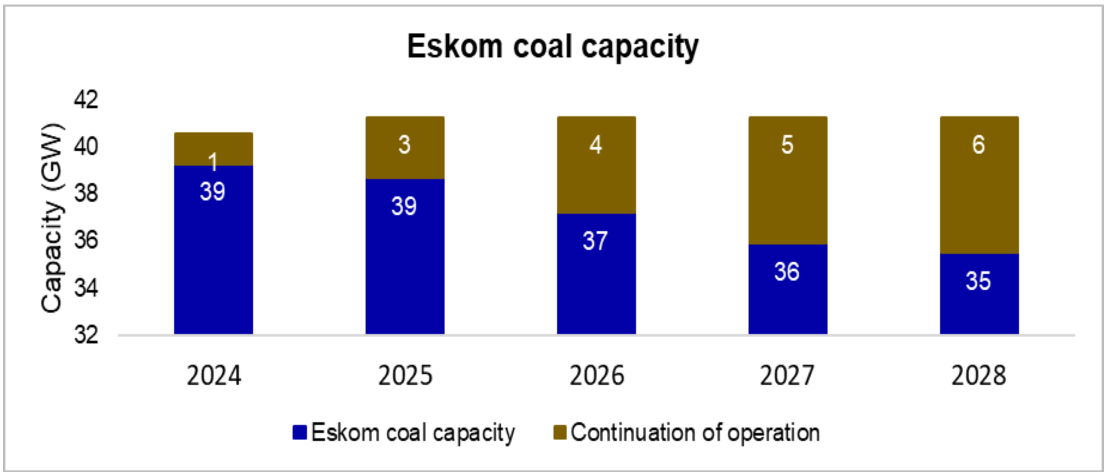


Figure 3: Eskom coal capacity

4.3.3 Kusile power station capacity

Additional capacity from the remaining Kusile Units 5 and 6 will add 1 440 MW of additional capacity to the grid. Kusile Units 5 and 6 are expected to reach commercial operation by May 2024 and February 2025, respectively. Kusile Units 1, 2, and 3 have been non-operational for most of 2023 as a result of the collapse of a flue gas duct in October 2022. However, Eskom has managed to return two of these units in October 2023, with only one unit still expected to return before the end of November 2023.

4.3.4 Eskom plant performance

The increasing unplanned outages have been the main contributor to the EAF performance decline, which has had a significant impact on the ongoing electricity supply challenges. Historical trend analysis based on the Eskom Technical Indicator Report (2023) shows steadily increasing unplanned outages as seen in Figure 4. Monthly generation capacity breakdown shows that unplanned outages reached values of 37.5%, 33.2%, and 33.9% from June 2023 to August 2023, which were mainly due to the loss of Kusile units. The monthly values for the same period in 2022 were 32.1%, 28.8%, and 30.7%, an increase of 4.3%. The low EAF, with an average of 50% for the MTSAO 2023 period, assumes that the historical downward trend in plant performance will continue in the medium term. This is purely the view meant as an indication of the system sensitivity should a major event occur and how the system adequacy might be impacted, this does not represent a planned position.

Eskom's immediate focus is on reducing load shedding, which will be achieved by improving the performance of the fleet through effective implementation of the EAF recovery programme. The programme aims to achieve a 65% EAF by the end of March 2024 and a 70% EAF by the end of March 2025. This will be delivered through an intensified focus on recovering performance at the worst-performing stations, while sustaining performance at the stations that have shown reliable performance.

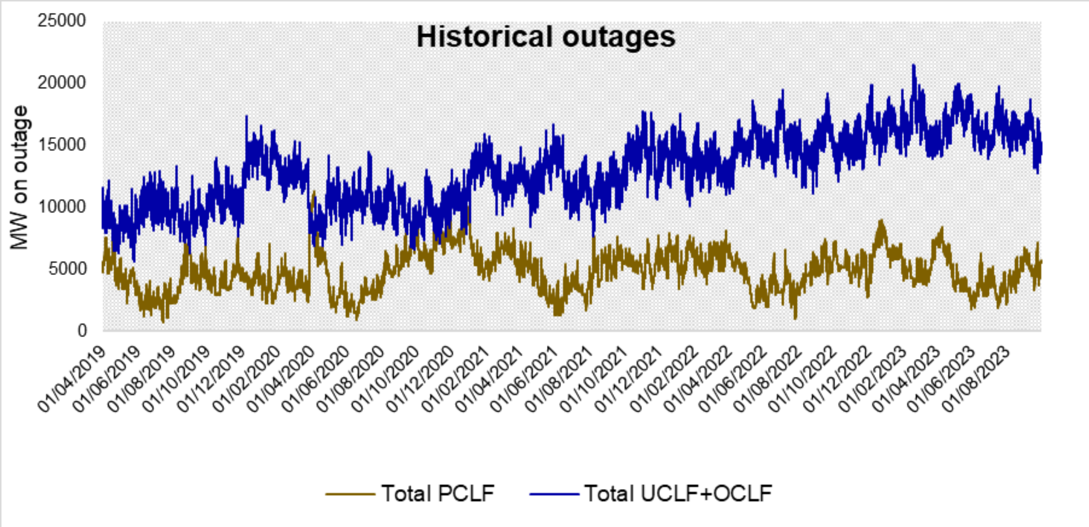


Figure 4: Historical Outages

However, the study has assumed a high EAF scenario starting at 59% reaching 68% by end of 2028 (averaging 65.2% for the MTSAO 2023 study period), which assumes that, although the maintenance planned in the Generation Recovery Plan has made some gains in arresting the decline in plant performance with a recovery seen year to date, the actual monthly EAF has been lower than initially expected in the recovery plan. The high EAF scenario is, hence, 1% to 3% lower than current Generation targets to accommodate the risk of lower-than-expected recovery for FY2024. The EAF scenarios used in the study are shown in Figure 5 below.

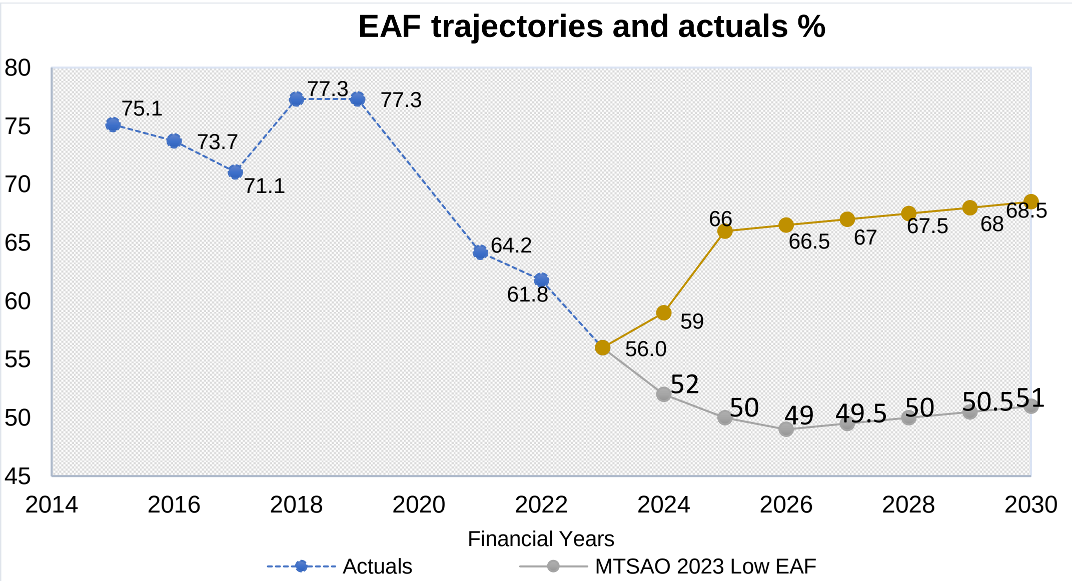


Figure 5: Plant performance scenarios

4.4 Non-Eskom capacity

4.4.1 Renewables from the Independent Power Producer Programme

The MTSAO 2023 study assumes cumulative capacity from the Renewable Energy Independent Power Procurement Programme (REIPPP) up to Bid Window 5 and the committed Risk Mitigation Independent Power Producer Procurement Programme (RMIPPPP) as reflected in Figure 6. The existing REIPPP capacity in commercial operation amounts to 6 181 MW. Current projections indicate that commercial operation of Bid Window 5 projects is on track, bringing the total capacity to 7 499 MW by 2026.

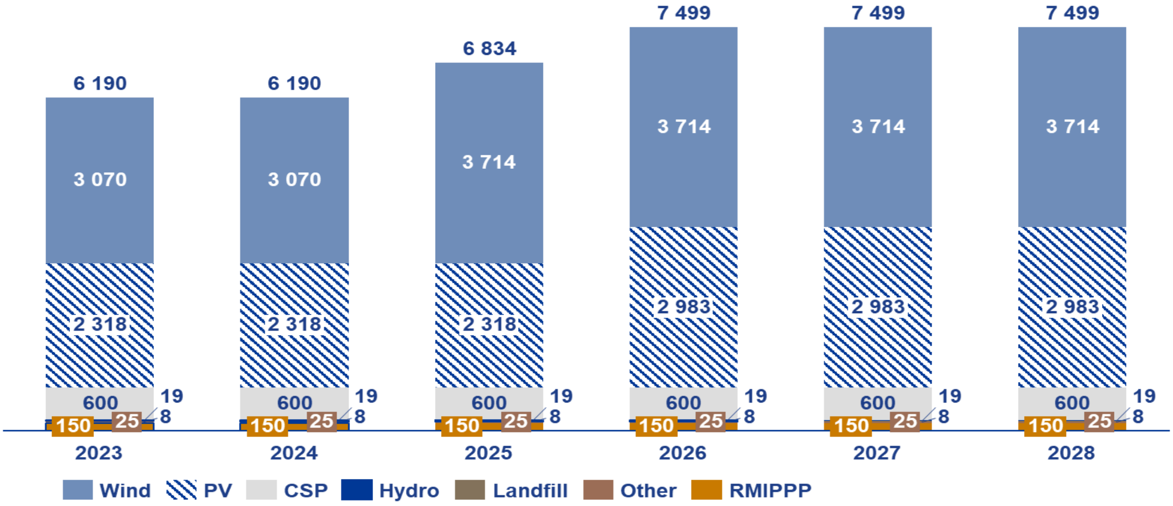


Figure 6: REIPPP and RMIPPP capacity MW

4.4.2 New generation capacity from NECOM initiatives and section 34

Additional determinations issued/to be issued by the Department of Mineral Resources and Energy in line with the gazetted IRP 2019 are not considered committed in the base case of the MTSAO 2023. However, these as anticipated generation capacity, they are considered as potential levers for identified supply shortages. Additional capacity outlined in the NECOM Energy Action Plan is also considered as a potential lever to close the gap. In closing the supply shortfall that has been identified, the MTSAO 2023 assesses the potential levers in the pipeline for development.

The NECOM initiatives target ~38.3 GW of new capacity coming onto the grid by 2030. Assumptions with regard to capacities and commercial operation dates of NECOM new generation initiatives have changed since the approval of the current targets. Hence for the MTSAO 2023 study, an updated outlook has been done using the current status of individual projects and the expected commercial operation dates thus resulting in a conservative view of anticipated capacity. Any project without location data or a forecasted commercial operation date has been excluded in the anticipated capacity due to those uncertainties.

The MTSAO has also excluded Karpowership RMIPPPP projects due to historic and current uncertainties with regard to progress with the projects. Figure 7 shows all the new build levers considered in this MTSAO.

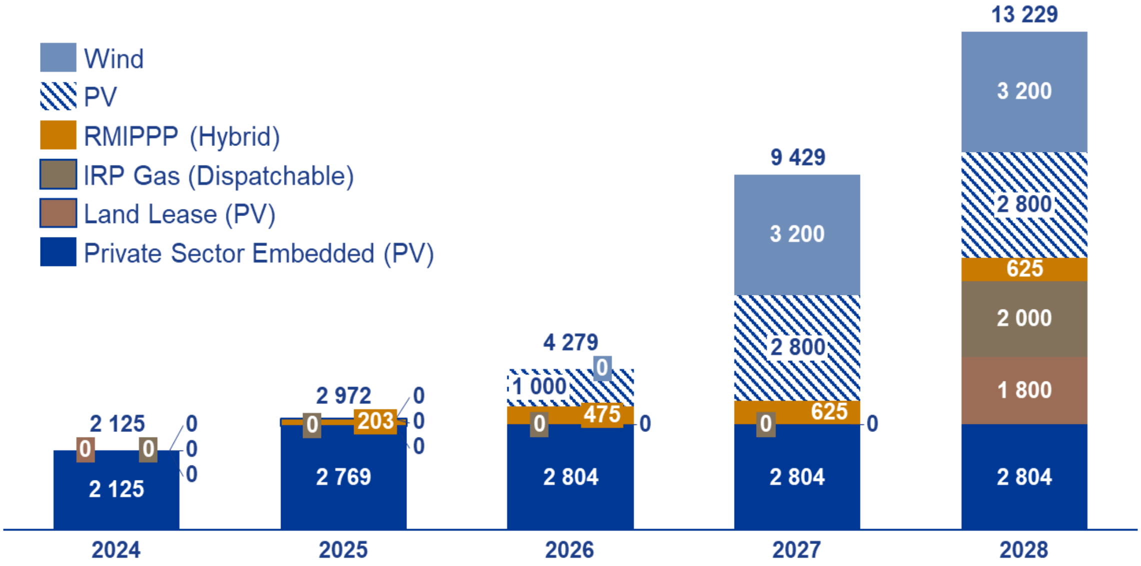


Figure 7: New generation capacity from NECOM initiatives and BWs 6 and 7

4.4.3 Small-scale embedded generation

Due to the unavailability of centralised validated data, the extent to which rooftop PV is installed remains a challenge. The System Operator has indicated that the embedded generation could be as high as 4 800 MW currently (Eskom weekly system status). The MTSAO has taken a conservative view and used the updated 2023 GreenCape assumptions. These figures show a higher penetration than the 2022 reported figures, which grew at 400 MW per annum, where updated assumptions are more than double.

Small-scale embedded generation – rooftop PV – is modelled as part of the base or reference case in the MTSAO 2023. Figure 8 shows the base installed capacity with an assumed growth rate of 880 MW per annum. This assumption is based on the report published by GreenCape in April 2023.

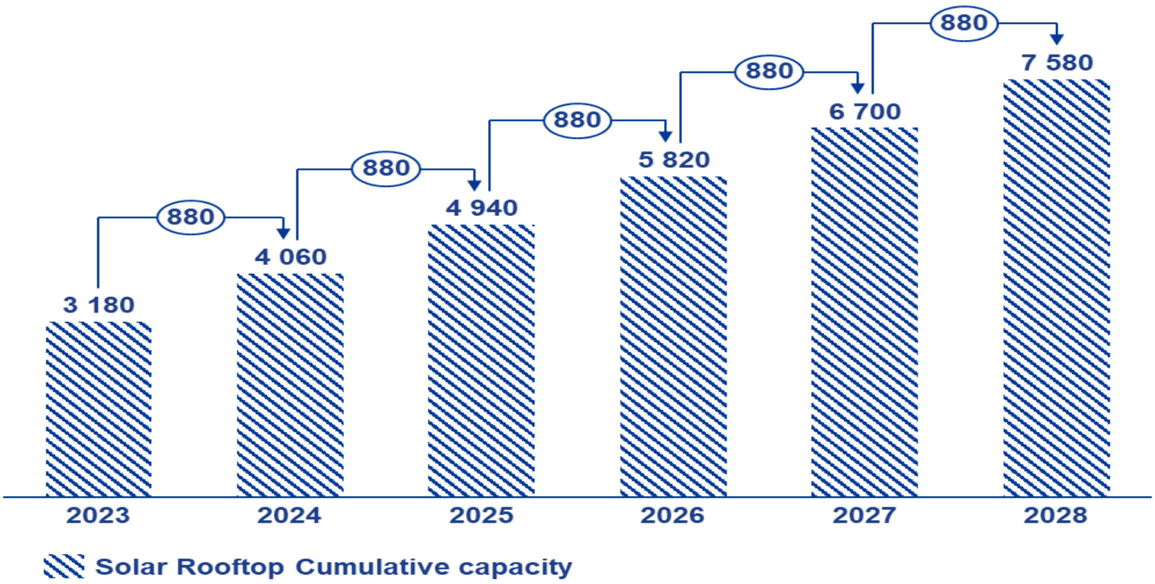


Figure 8: Small-scale embedded generation

4.4.4 Other non-Eskom capacity licensed by NERSA

The MTSAO 2023 has also considered non-Eskom generation capacity, which produces 9.15 TWh (excluding Avon, Dedisa, and Cahora Bassa hydro import), as shown in Figure 9. The MTSAO 2023 has inferred typical plant performance by referencing plant of comparable size and age due to unavailable data for non-Eskom power plants. Furthermore, the study has projected similar energy production for the future based on historical performance, which is expected to hold during the MTSAO planning horizon. Therefore, any unforeseen decline in the production of these generators will have a negative impact on power system adequacy.

Additional capacity also considered in the study includes the 1 005 MW of DMRE independent power producer (IPP) peaking plants at Dedisa and Avon and the 1 100 MW Cahora Bassa import.

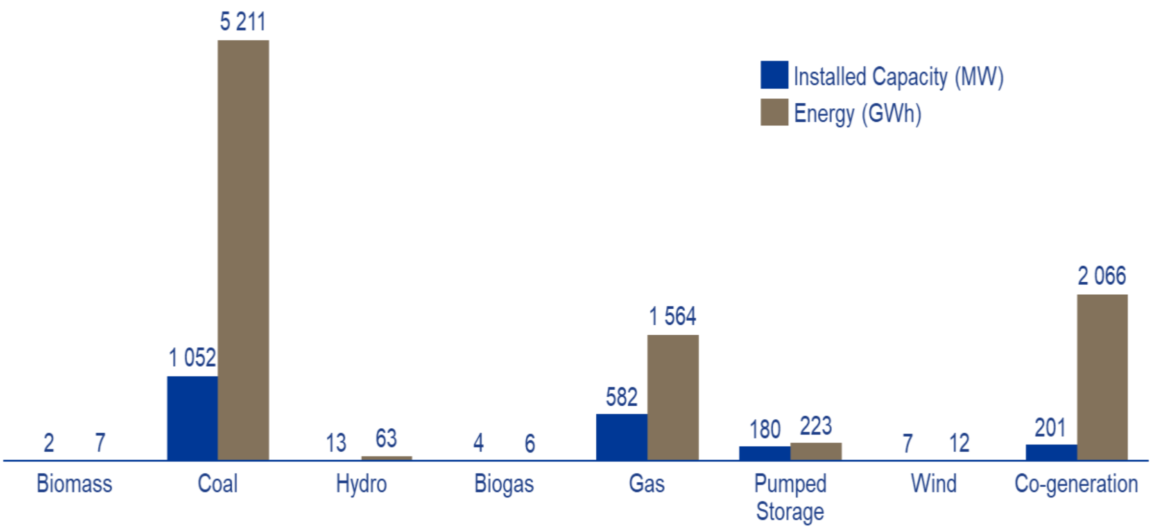


Figure 9: Non-Eskom capacity and energy

4.4.5 Grid-constrained capacity

The constrained transmission grid poses a risk in integrating new generation capacity. This will lead to a negative impact on system adequacy by delaying new generation projects or preventing them from being undertaken entirely. Eskom's Grid Access Unit has already issued sufficient budget quotations to allow connection of private sector projects modelled in the MTSAO 2023 as a lever; however, the REIPPP Bid Window 7 projects remain at risk and have been modelled as such by reducing the new capacity by 5 000 MW.

Table 2: Grid-constrained new generation capacity from NECOM initiatives

	2024	*2025*	*2026*	*2027*	*2028*
Grid-constrained new build capacity (MW)	2 125	2 972	4 279	4 429	8 229

5. STUDY CASES

The studied scenarios were selected to cater for the unpredictable nature of the South African integrated power system. The most likely paths for electricity demand and plant performance (based on current performance figures) were identified as the low EAF and moderate demand paths, and as such, these form the reference case as listed below. The high EAF path was also studied to demonstrate the effect of improving plant performance on system adequacy.

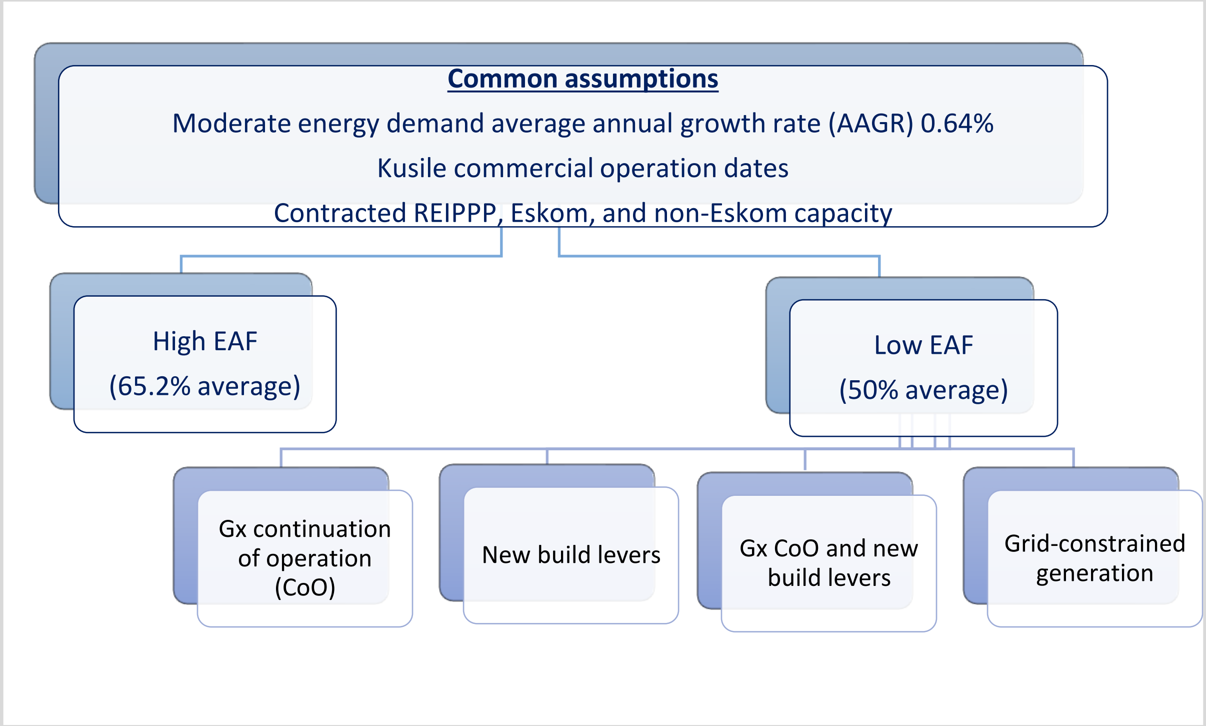


Figure 10: Study cases

6. RESULTS

6.1 Adequacy metrics results of scenarios modelled

The results of the MTSAO 2023 are shown in Table 3 and Table 4 below. The low EAF scenario (reference case) shows a severely inadequate power system from 2024 to 2028, with the unserved energy and OCGT capacity factor far exceeding the adequacy metrics of 20 GWh and 6%, respectively, in all years.

The Gx continuation of operation scenario serves to relieve the system to some extent, but without EAF improvement or the addition of new build levers, this scenario falls short of restoring the system to adequacy.

Applying all available new build levers improves both the unserved energy and OCGT capacity factor, with the largest improvements coming in 2027 and 2028 due to the impact of 3 000 MW of dispatchable IRP gas plant added to the system over this period. The transmission grid-constrained scenario naturally performs similar to the lever's scenario in the initial years and becomes relatively more inadequate in 2027 and 2028 due to the loss of Bid Window 7 PV and wind.

Combining new build levers with continuation of operation further improves the system. While the unserved energy dips to 206 GWh by 2028, this combination remains insufficient to restore the system to adequacy in the short term.

Contrary to the above results, EAF improvement alone appears to be sufficient to restore the system close to adequacy, with a slightly high unserved energy in 2027 and 2028 due to Eskom plant shutdown. The OCGT capacity factor, however, remains below 6% in all years in this scenario, indicating that the problem may be a peaking capacity issue rather than an energy issue as with all other scenarios.

Table 3: Unserved energy results for all study cases

SCENARIO	2024	2025	2026	2027	2028	Adequacy
High EAF	34	25	84	235	323	
Low EAF	13 379	11 995	19 887	23 024	22 504	
Gx Continuation of Operation	11 299	7 690	5 367	4 758	4 405	
New Build Levers	10 832	8 704	12 392	8 001	2 700	
Grid Constrained	12 997	11 370	15 364	17 879	6 816	
Gx Continuation and New Build Levers	8 930	5 545	2 692	1 036	206	

Table 4: OCGT capacity factor for all study cases

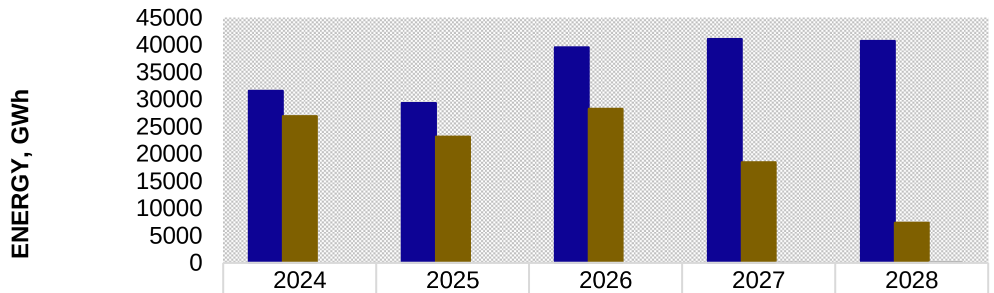
SCENARIO	2024	2025	2026	2027	2028	Adequacy
High EAF	2	1	2	3	4	
Low EAF	64	61	70	71	70	
Gx Continuation of Operation	60	50	39	34	31	
New Build Levers	58	51	57	40	18	
Grid Constrained	63	59	64	64	39	
Gx Continuation and New Build Levers	58	45	29	13	3	

6.2 Energy gap results

The energy gap requirements refer to the additional energy needed to restore power system adequacy. To simulate the energy gap, OCGT operation was constrained to an annual capacity factor of 6%, and the resulting unserved energy was reported.

Closing this energy gap will require a combination of new capacity and increased availability of existing capacity. Dispatchable capacity can mitigate supply shortfalls arising from the random nature of unplanned outages and intermittency of generation resources in the system. Variable generation resources will reduce the energy gap if the degree of their energy production and the demand shortfall coincide. There may be instances where the degree of coincidence between the two is low or non-existent. In such instances, new/additional generation resources will be required to reduce the shortfall further.

Figure 11 shows that the reference case energy gap remains high in all the years and peaks at 41 TWh in 2027. The new build levers scenario, which is marginally lower, peaks at 28 TWh in 2026. The energy gap in the high EAF scenario matches the unserved energy in the unconstrained case, given that the OCGTs are already operating below 6% in this particular scenario. This suggests that the energy deficit in the high EAF scenario is attributed to peak demand challenges rather than a fundamental energy shortage.



	2024	2025	2026	2027	2028
Reference-Low EAF	31578	29341	39587	41103	40743
New Build Levers	26907	23178	28273	18489	7359
High EAF	34	25	84	235	323

Figure 11: Energy gap results

7. SENSITIVITIES

While the study cases in section 5 were designed to fully understand the impact of key parameters on the adequacy of the power system, other factors were identified that, if they materialised, would likely have a major impact on the system. This section unpacks and assesses their impact, where possible.

7.1 Koeberg life extension delay

The IRP 2019 acknowledged that Koeberg Nuclear Power Station would reach the end of its design life in 2024. However, for continued energy security in the period beyond 2024 and to ensure continuity of nuclear power in the energy mix, Koeberg is undergoing design life extension. The IRP 2019, furthermore, recognised that Eskom was at an advanced stage with technical work required for the extension of the life of the Koeberg plant, which would enable Eskom to apply for the necessary approvals to extend its nuclear operating licence with the National Nuclear Regulator (NNR). In the licence application for the long-term operation of Koeberg that was submitted to the NNR, the replacement of the steam generators was identified as being a prerequisite for the station to operate safely beyond its original licensed operating period of 40 years.

The MTSAO 2022 considered the impact of possible delays of Koeberg's life extension by two years, based on the delays in the steam generator replacement project at the time, resulting in a loss of 1 860 MW. However, the steam generators on Unit 1 have been successfully replaced, and the unit is expected to be synchronised to the grid by the end of October 2023. Unit 1 will reach 40-year operation in July 2024, and it is expected that, by that time, it will have been awarded the extension to operate beyond 40 years. The three steam generators on Unit 2 are scheduled for replacement in the upcoming Unit 2 outage, which will start in mid-November 2023. The Koeberg team is using the experience gained from the installation on Unit 1 to reduce the outage period required to replace the steam generators on Unit 2; hence, there is minimal risk of a delay on Unit 2. Koeberg Unit 2 will reach 40 years of operation in November 2025.

It remains important that the licence expiry dates for both units be separated based on their 40-year operation to mitigate having both units reach their licence expiry date at the same time.

7.2 Minimum emission standards

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. Since the MTSAO 2021 report on the MES, the following has transpired:

7.2.1 MES decision

On 4 November 2021, the DFFE made available 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 the DFFE took was for Eskom to strictly comply with prescribed limits for local pollutants. Specifically, exemptions were granted at the coal-fired power stations Arnot, Camden, Grootvlei, Hendrina, Komati, and Kusile, as well as Acacia and Port Rex liquid-fuel-fired power stations. However, applications for postponements at Duvha, Lethabo, Matimba, Matla, and Medupi were declined completely, while those for Kendal, Kriel, Majuba, and Tutuka were partially granted in the form of either suspensions or alternative air quality limits. When implemented, the decision will result in the loss of baseload generation capacity.

i. Loss of 15.9 GW immediately on implementation of the MES decision
ii. Loss of 29.9 GW after April 2025 when current postponements lapse on 31 March 2025

This will have a significant negative impact on Eskom's mandate to supply stable and reliable electricity to meet the needs of the country. Following the review of the decision, Eskom engaged the DPE, the DFFE, and the DMRE and, ultimately, opted to appeal the decision in terms of the National Appeal Regulations. Because of the complex and conflicting nature of the decision, the Minister of the DFFE tabled and proposed[1] at Parliament that an appeals forum be constituted. A forum named the National Environmental and Consultative Advisory (NECA) was nominated and subsequently appointed to oversee a public participation process to assess, review, and report to the Minister on the impact of the decision, considering air quality, public health, and security of energy supply.

7.2.2 National Environmental and Consultative Advisory (NECA) Forum

The NECA Forum has been constituted in terms of section 3A of the National Environmental Management Act 107 of 1998 to advise the Minister of the DFFE on matters arising from the applications for the suspension and postponement of compliance with the MES and the applications for the issuance of provisional atmospheric emissions licences. The forum has been asked to develop practical options for the Minister to resolve issues arising from non-compliance with the MES. In this, the forum is, inter alia, required to consider the technology options available to Eskom, their technical implications and cost, and the impact that these options will have on electricity supply and the stability of the grid. Furthermore, the forum has been tasked to consider the Minister's constitutional and legislative mandate and the international commitments of the country, the health and well-being of people, the energy crisis, and the local economic climate.

Eskom and other interested and affected parties have been invited to contribute to technical briefings hosted by the forum. The focus is on outlining emission control measures taken to date and future emission reduction plans developed, considering current and foreseen financial and resource constraints. Additionally, the outcomes of energy supply constraints, financing, and grid issues evaluated from the impact of the decision will be presented.

7.2.3 Public participation and next steps

The forum held public stakeholder meetings with affected communities in November 2022 and has since appointed independent experts to model various scenarios of the power system in order to provide information on the implications of different recommendations for national security of power supply, the cost of providing electricity, and South Africa's power sector greenhouse gas emissions.

8. CONCLUSIONS AND RECOMMENDATIONS

South Africa has been faced with power supply constraints for over 10 years, with 2023 being the worst year of load shedding at 14.4 TWh as at the end of September. This has been exacerbated by the loss of three units at Kusile Power Station due to a flue duct collapse and the delayed return of Koeberg Unit 1 from the steam generator replacement outage. With the Kusile units and Koeberg units returning to service before the end of the year 2023, the system is expected to be less constrained. However, any other disruption to the already fragile power supply will have a detrimental effect on the ability of the system to provide secure and reliable electricity to the consumer. The penetration of rooftop PV by residential and commercial customers has also helped to ease the power generation constraints.

Although the study has taken a conservative view on the addition of new capacity, it is still crucial that the initiatives to meet the NECOM targets be continued, as these will set the country on a path to recovery and growth. The procurement process of new generation initiatives is traditionally a prolonged process, and that has been one of the contributing factors to the constrained system. As additional measures, NECOM has undertaken to enable and accelerate private investment in generation capacity and accelerate procurement of new capacity from renewable energy, gas, and battery energy storage systems.

The study indicates that, if the plant performance decline is not arrested and new generation capacity is not rolled out timeously, the situation will worsen as the demand grows. The results of this MTSAO have shown the following:

- The low EAF scenario is severely inadequate, regardless of the new generation initiatives.
- The high EAF scenario is adequate in all the years of study, and this will support economic growth.
- The continuation of operation of the existing generation fleet, albeit at a low EAF, improves the system adequacy. The performance of the units that are candidates for continuation of operation needs to be improved.
- The impact of new build levers on the adequacy significantly improves when the 2 000 MW of dispatchable gas is introduced in the later years of the study.

To restore power system adequacy in the medium term, the MTSAO 2023 recommends the following:

- A combination of improved plant performance and the addition of new capacity will greatly improve system adequacy.
- The previous MTSAO studies reported that Eskom had initiated a Generation Reliability Maintenance Recovery Programme with the objective of doing deep refurbishment and having maintenance requirements to improve the system EAF. However, the evidence, as seen in **Error! Reference source not found.**, shows a t rend of outages that continues to increase, thereby decreasing system EAF. Given that the EAF is the biggest lever to system adequacy and that the historical trends reflect a downward trajectory, it is crucial that the current maintenance regime be reviewed to improve its efficacy.
- Recent studies such as Eskom Transmission's Generation Connection Capacity Assessment (GCCA) report note that issues of the grid are a challenge to address in the medium term. The latest report notes that the limiting factor for connecting new generation resources is that the areas with the best solar or wind resources lack connection infrastructure. This is primarily the Greater Cape area, comprising the Western Cape, Northern Cape, and Eastern Cape networks that require "substantial upstream network strengthening to facilitate new generation capacity". Therefore, transmission development projects need to be expedited to unlock potential generation initiatives.
- Compliance with the MES remains a big area of uncertainty. Until the final decision by the Minister of Forestry, Fisheries and the Environment has been made, this will remain a threat to capacity.
- More emphasis should be placed on timeously extending the life of Koeberg Power Station, as the loss of Koeberg units will have a significant impact on adequacy in the short term.

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 2023 year to date as at end of September 2023, with data available for retrieval from the Eskom Data Portal (2023).

9.1 Performance of Reserves

Table 5 shows 2022 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: 2022 Frequency incidents

2022	*49.5 < f < 49.7*	*f < 49.5*	*f>50.3*	*50.5 > f > 50.4*	*f > 50.5*
Jan	134	2	62	2	0
Feb	150	2	63	2	0
Mar	141	5	31	1	0
Apr	91	4	58	6	0
May	126	3	40	1	0
Jun	177	4	130	25	3
Jul	136	4	116	15	3
Aug	97	4	54	4	1
Sep	345	6	105	8	1
Oct	156	3	40	3	2
Nov	155	2	43	5	2
Dec	210	8	31	2	0

9.2 OCGT Utilisation

Gas peaking capacity dispatchable by the System Operator includes Eskom's Ankerlig (1 327 MW) and Gourikwa (740 MW) as well as the DMRE OCGTs at Dedisa (335 MW) and Avon (670 MW). Generation from these resources over the past seven years is depicted in Figure 12 below. The usage of OCGTs to balance supply and demand has increased significantly from 2019, and the 2023 YTD utilisation is higher than the full year 2022, likely to increase further into the summer months.

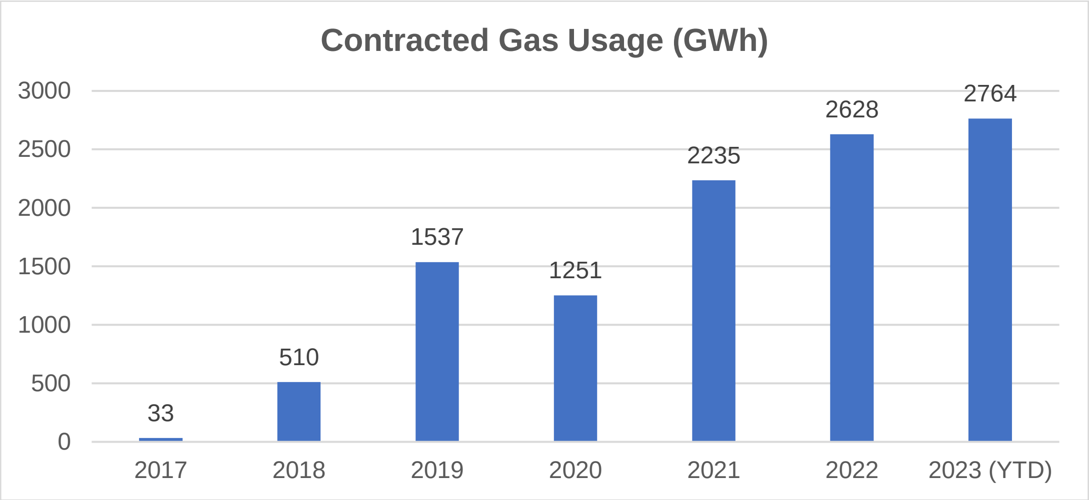


Figure 12: Actual OCGT utilisation 2017 to 2023 YTD

9.3 Unserved Energy

Due to a shortage of supply, the System Operator implements load shedding and/or curtailment of demand to ensure a stable power system. Figure 13 shows historical recorded energy not supplied due to emergency load reduction as 14.58 TWh for the current year to date. Significant increases can be observed from 2022 to the current year to date, indicating an inadequate system.

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.

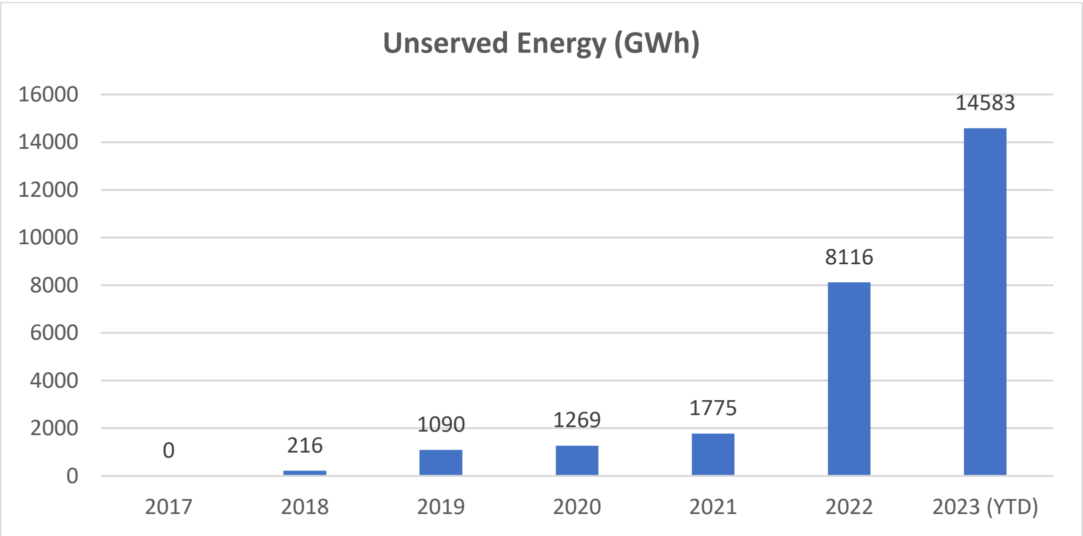


Figure 13: System Operator instructed load shedding for the calendar year 2017 to 2023 YTD

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