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MEDIUM-TERM SYSTEM ADEQUACY OUTLOOK

30 OCTOBER 2022

Generation System Adequacy for the Republic of South Africa

MEDIUM-TERM SYSTEM ADEQUACY OUTLOOK

Purpose

The purpose of this publication is to inform electricity consumers of the status of the power system adequacy as well as foreseeable futures that may arise based on the information at hand. The study is not intended to be used as a plan but rather to explore how possible different futures might test the adequacy of a generation system.

Disclaimer

While the System Operator has taken all reasonable care in the collection and analysis of data available, 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 1 August 2022, unless otherwise indicated.

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List of abbreviations and definitions

Term/Abbreviation	Definition
Capacity factor (CF)	Measures how hard the plant is running against its maximum possible output.
Department of Forestry, Fisheries and the Environment (DFFE)	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.
Department of Mineral Resources and Energy (DMRE)	Government department mandated to ensure secure and sustainable provision of energy for socio-economic development.
Department of Public Enterprises (DPE)	Government department mandated to perform shareholder oversight on behalf of the government.
Energy Availability Factor (EAF)	The percentage of the maximum energy a plant can supply to the grid when not on planned or unplanned outage.
Forced Outage Rate (FOR)	The fraction of time (annually) that units at the generator are expected to be unavailable because of random failures.
Gross Value Added (GVA)	The value generated by any unit engaged in producing goods and services.
Integrated Resource Plan (IRP)	A generation capacity expansion plan based on least-cost electricity supply and demand balance in the long term.
Planned Outage Rate (POR)	The fraction of time (annually) that units are out of service because of scheduled maintenance events.
Minimum emission standards (MES)	Regulation published under the National Environmental Management: Air Quality Act (NEMAQA) 39 of 2004.
National Energy Crisis Committee (NECOM)	A committee formed by the President of the Republic to end load shedding.
National Energy Regulator of South Africa (NERSA)	A regulatory authority established as a juristic person in terms of section 3 of the National Energy Regulator Act 40 of 2004.
Energy National Joint Operational and Intelligence Structure (NATJOINTS)	A structure providing technical oversight to the NECOM.
National Nuclear Regulator (NNR)	The legal entity established in terms of the National Nuclear Regulator Act 47 of 1999.
Open-cycle gas turbine (OCGT)	A combustion-type turbine using liquified/gas fuel typically for emergency periods.
Renewable Independent Power Producer Programme (REIPPP)	A vehicle set up to procure electricity from renewable and non-renewable energy sources from the private sector.
Risk Mitigation Independent Power Producer Programme (RMIPP)	A programme designed by the DMRE to fulfil the Minister’s directive identified by the IRP 2019 gazette.
Small-scale embedded generation (SSEG)	Power generation facilities located at residential, commercial, or industrial sites, where electricity is generally also consumed and may be exported onto the grid.
System Operator (SO)	An entity within Eskom entrusted with ensuring continuous and reliable delivery of electricity.

1. Executive summary

The Medium-term System Adequacy Outlook (MTSAO) is a generation assessment that measures the electric power system's ability to meet demand over the next five calendar years within acceptable levels of reliability as defined by the adequacy metrics. The current MTSAO for the period 2023 to 2027, hereinafter referred to as MTSAO 2022, considers the following key assumptions:

Demand assumptions:

i. The low-demand forecast has an annual average growth rate of -0,3%.

ii. On the other hand, the moderate-high demand forecast has an annual average growth rate of 1% and is linked to a GDP growth rate of 1,88%.

Plant performance assumptions:

iii. Low EAF: This is a statistically derived EAF forecast based on historical trends and depicts an EAF that averages 58% annually in the study period.

iv. High EAF: This scenario depicts an EAF that improves to 68% by the end of the study period.

Four reference scenarios are studied using two EAFs and two demand forecast trajectories. The study further assesses the impact of new generation capacity from the IRP 2019 Bid Windows 5 to 8 as additional levers. Additionally, the impact of a two-year delay in the life extension of the Koeberg Nuclear Power Station on the system's ability to meet demand within acceptable reliability is tested.

The result of this MTSAO shows the following:

- ✓ The low EAF scenario is severely inadequate irrespective of the demand forecast scenarios.
- ✓ The high EAF and moderate-high demand scenario is likewise inadequate.
- ✓ The high EAF and low-demand scenario is marginally inadequate, which does not support further electricity sales.
- ✓ The addition of IRP 2019 Bid Windows 5 to 8 generation capacity helps but does not sufficiently restore the inadequate scenarios to adequacy.
- ✓ A delay of Koeberg’s life extension by two years will severely constrain the system and exacerbate the inadequacy.

The following is observed from the energy gap analysis:

- ✓ The worst-case scenario shows that the energy required to restore the system to the adequacy is 18 TWh in 2023, increasing to 30 TWh in 2027. The energy gap of 18 TWh in 2023 is equivalent to Matla Power Station production at full load.
- ✓ With the addition of IRP 2019 generation capacity from 2024, the energy gap reduces from 15 TWh to 9 TWh in 2024 and from 30 TWh to 7,9 TWh in 2027.
- ✓ Delaying Koeberg’s life extension is not desirable since it increases the energy required by 15 TWh per year over and above the energy needed without delays.

2. Introduction

The Medium-term System Adequacy Outlook (MTSAO) assesses the electricity power system's ability to meet demand within predefined adequacy thresholds in the next five calendar years. The current study covers the calendar years 2023 to 2027 and is referred to as the MTSAO 2022.

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

- ✓ consumers of the depth of the risk, that is, the amount and nature of demand not served;
- ✓ consumers of the likely timing of supply risks, be it the time of day or time of year (the volume of the energy gap may dictate the nature of the generation resources as baseload or peaking required to restore system adequacy);
- ✓ policymakers with foresight to procure sufficient generation resources, that is, when and how much additional energy is required to meet expected demand; and
- ✓ consumers with the opportunity to prepare for a possible interruption in supply.

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 IRP. Furthermore, the MTSAO does not assess the adequacy of the grid needed to transport 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.

The MTSAO is published annually in compliance with the South African Grid Code (SAGC: System Operator Code January 2022), which requires the System Operator (SO) to publish it on or before 30 October each year. In so doing, the SO is required to consider the following:

- ✓ possible scenarios for growth in the demand of electricity consumers. The expected demand includes South Africa's demand plus exports to neighbouring countries;
- ✓ possible 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 (NERSA) plus imports from neighbouring countries, demand-side management resources, and distributed generation;
- ✓ possible scenarios for new and committed generation projects; and
- ✓ any other information that the SO may reasonably deem appropriate.

3. Methodology

Figure 1 shows the MTSAO process where input data consisting of demand forecast and generation resources as licensed by NERSA, 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 simulations address the random nature of these stochastic parameters since they are intermittent and impossible to predict accurately. The Monte Carlo simulation method computes optimal decisions for many possible outcomes, 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.

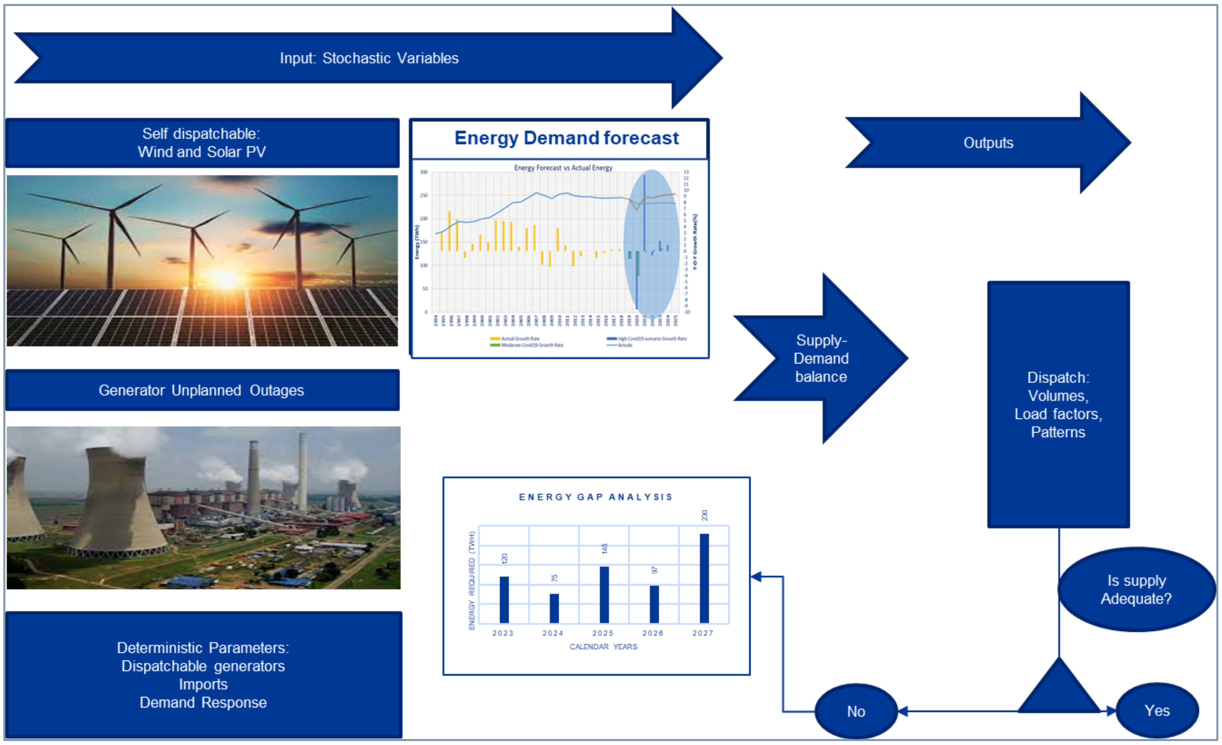

Figure 1: MTSAO methodology

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 satisfies 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.
III. The capacity factor of the contingency base load station is less than 50% 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. Assumptions

This section details key assumptions used in the development of the MTSAO 2022.

4.1 Energy demand forecast

Two demand forecast scenarios shown in Figure 2Figure **2** were considered in this MTSAO, namely,

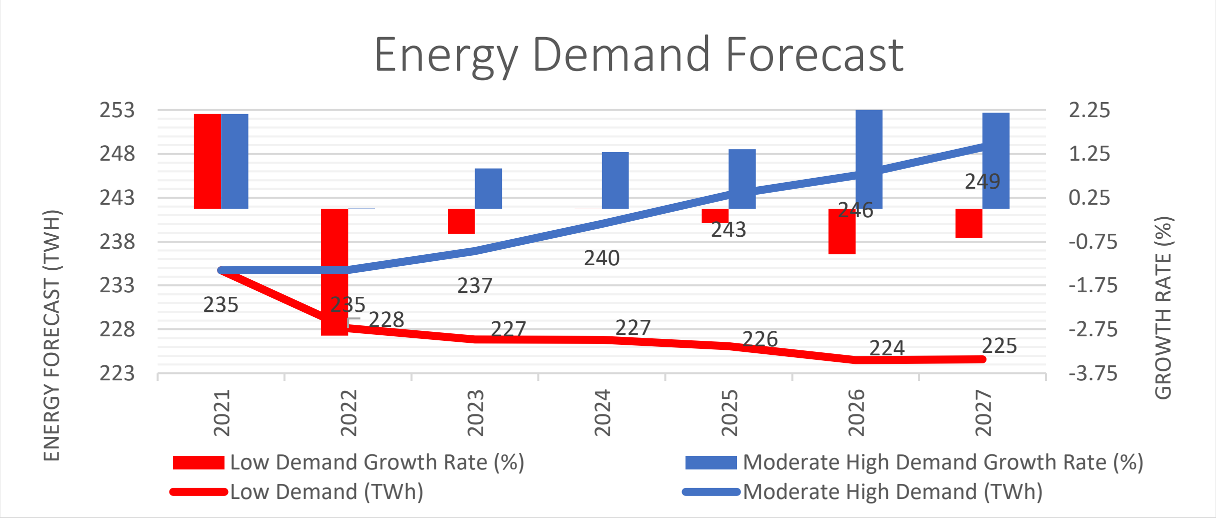

Figure 2: Possible energy demand forecasts

Low demand: This demand scenario has an annual average growth rate of -0,3% and is derived from Eskom's sales projections, considering the volume and timing of potential extensions and/or shutdowns of customer operations.

i. Moderate-high demand: This scenario has an annual average growth rate of 1% and uses GDP as an input into econometric models to calculate the Republic of South Africa's energy sent out correlated to the respective economic growth of the country. The GDP forecast from the regional eXplorer (ReX) update of the first quarter of 2022 has an average GDP growth for the MTSAO period of 1,9%, which compares well in the short term with other institutions, such as Fitch Solutions and the IMF.

The moderate-high scenario expects more economic contribution from primary and secondary sectors, which houses highly electricity-intensive sectors such as mining and manufacturing. The modelling of these contributions is calculated using Gross Value Add (GVA), which is a driver of the different production indices of the industrial sectors. As a result, any positive change to the contributions of the primary and secondary sectors will yield favourable growth in their respective electricity sectors.

4.2 Plant performance

Figure 3 shows historical trends of planned and unplanned outages (Eskom Data Portal 2022), indicating increasing unplanned outages contributing to deteriorating plant performance.

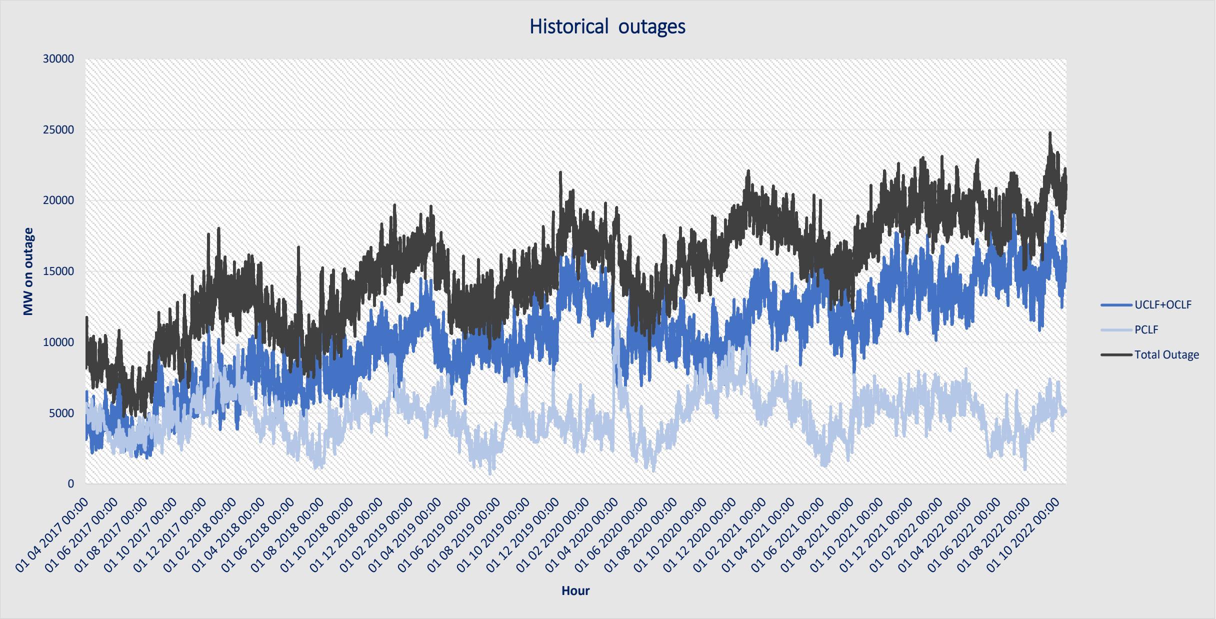

Figure 3: Historical total outages (MW)

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The SO expects a downward trend in plant performance to continue in the medium term, fueled by increasing unplanned full and partial load losses, particularly given that the current calendar year-to-date EAF is 57,8% as at the week ending 16 October 2022.

Therefore, a more likely low EAF, with an annual average of 58% for the study period, is considered the base case of the MTSAO 2022. A higher EAF, averaging 67%, aligned with Eskom Generation's plan, was also considered for assessment, as shown in Figure 4. The EAF, averaging 67%, assumes that maintenance planned in the Reliability Maintenance Recovery Programme will be able to arrest the decline in the plant performance.

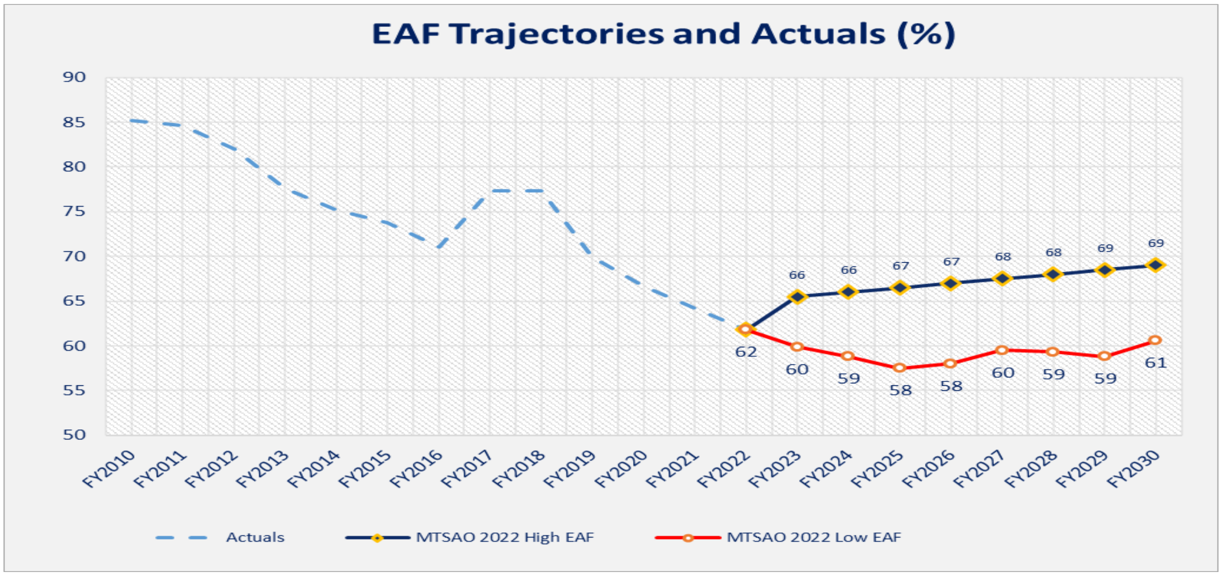


Figure 4: EAF trajectories and actuals (%)

4.3 Eskom fleet shutdown

Figure 5 shows that Eskom's generation fleet is expected to reduce by 5 288 MW between 2023 and 2027 because of plants reaching their turbine dead-stop dates (DSD). Acacia and Port Rex will reach end of life within the study horizon; other units that will be shut down are the two units from Kriel, four units from Arnot, eight units from Camden, six units from Hendrina, and two units from Grootvlei.

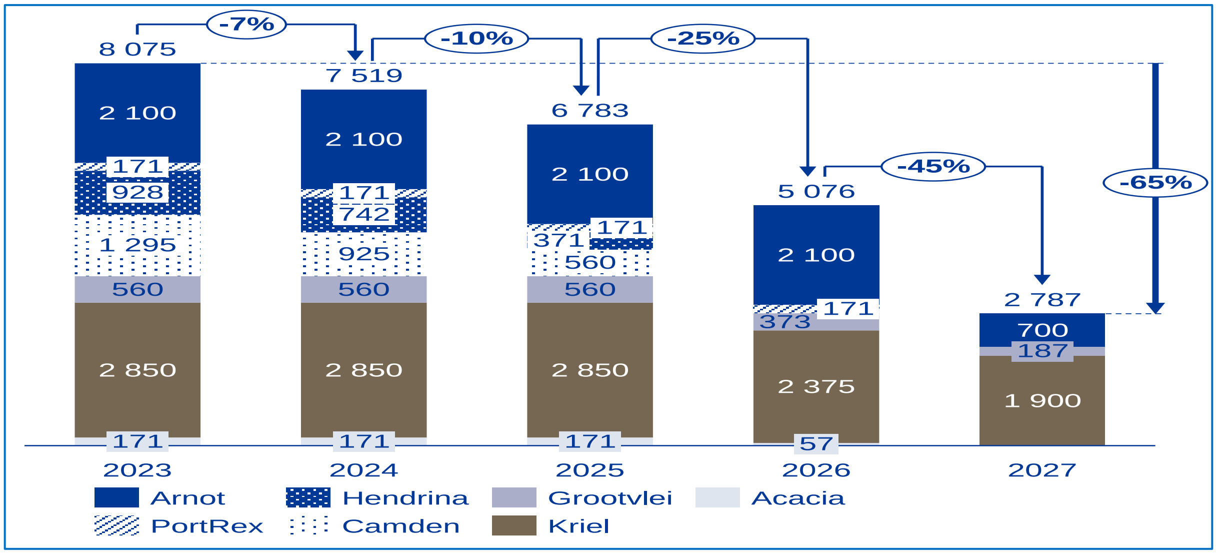


Figure 5: Assumed capacity shutdown from 2022 to 2027

Koeberg Power Station would ordinarily reach its 40-year end of design life in 2024. However, in line with the IRP 2019, it is envisaged that all nuclear safety/regulatory licences and the steam generator replacement project will be expedited to extend Koeberg's life by an additional 20 years. No impact on the 1 860 MW capacity is assumed in the base case of MTSAO 2022. The potential delay in Koeberg's life extension is considered a risk and studied as a sensitivity.

4.4 New build stations

Since the publication of the MTSAO 2021, Eskom's new build capacity that achieved commercial operation is Kusile Unit 3 in May 2022. Although all Medupi units have reached commercial operation, the MTSAO 2022 opted to reduce Medupi capacity to account for the damaged Unit 4, which is expected to return to operation in August 2024.

Kusile Unit 4 was synchronised on the grid on 31 July 2022. The remaining two Kusile units are assumed to achieve commercial operation by December 2023 and May 2024. Figure 6 shows the cumulative capacity from the remaining Kusile units and Medupi Unit 4.

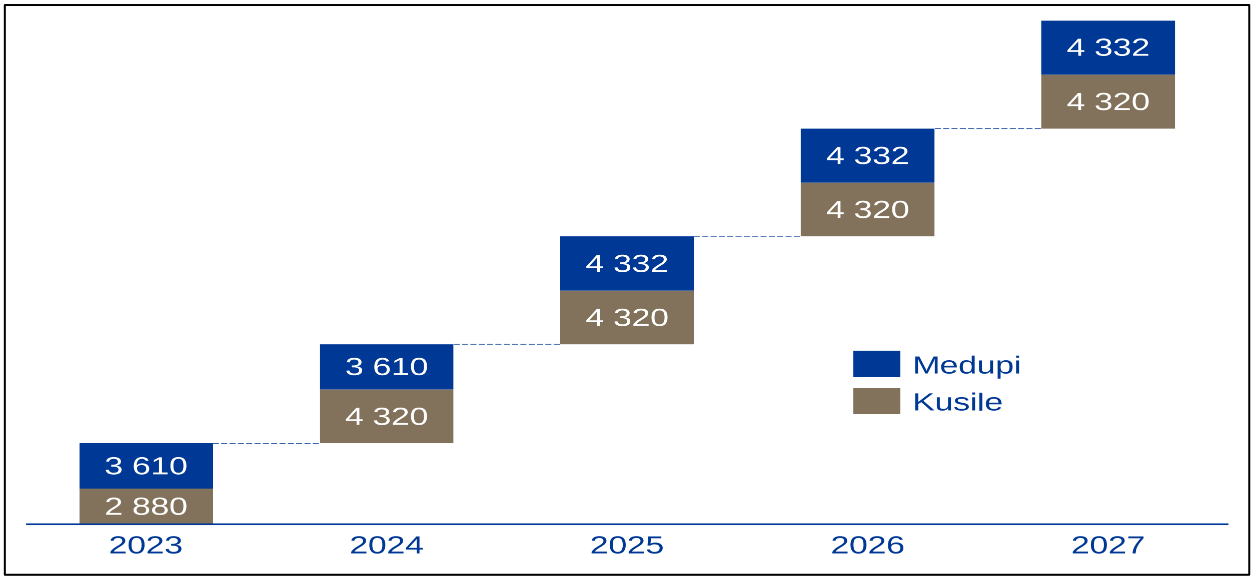


Figure 6: Committed new build capacity (MW)

4.5 Renewables from the Independent Power Producer Programme

The MTSAO 2022 study assumes cumulative capacity from the Renewable Energy Independent Power Producer Programme (REIPPP) up to Bid Window 4+ and the committed Risk Mitigation Independent Power Producer Procurement Programme (RMIPPPP) as reflected in Figure 7 . The existing REIPPP capacity in commercial operation amounts to 6 105 MW. Current projections are that commercial operation of the remaining two projects, the solar PV and CSP facility, are on track to be realised by the end of 2022 and early 2024, respectively, bringing the total capacity to 6 280 MW. The three projects from the RMIPPPP signed in June 2022 are expected to be operational in November 2023 and collectively have 150 MW contracted capacity comprising a hybrid solar PV and battery configuration.

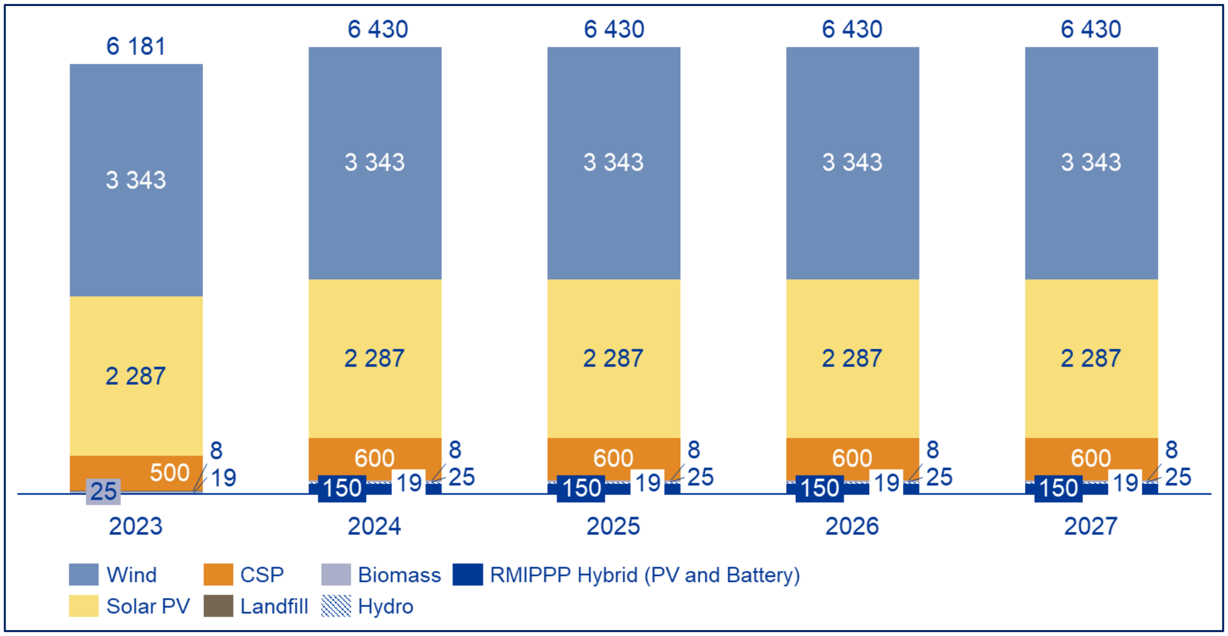


Figure 7: REIPPP cumulative capacity (MW)

Additional determinations issued/to be issued by the DMRE in line with the gazetted IRP 2019 are not considered committed in the base case of the MTSAO 2022. However, these are regarded as potential levers for identified supply shortages.

4.6 Other non-Eskom capacity licensed by NERSA

The MTSAO 2022 also considered non-Eskom generation capacity (excluding Avon, Dedisa, and Cahora Bassa hydro import), which produces ~ 11 TWh, shown in Table 1. Additional capacity 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. The MTSAO assumed typical plant performance based on plant of similar size and age because of the unavailability of data for non-Eskom power plants. Furthermore, the study 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.

Table 1:non-Eskom capacity and energy

	Installed capacity (MW)	*Energy (GWh)*
Coal	1 832	6 038
Hydro	17	58
Biogas	4	8
Gas	507	2 229
Pumped storage	180	166
Cogeneration	331	2 058
Wind	7	11
Biomass	1,5	7

4.7 Potential levers to close the supply gap modelled in the MTSAO 2023-2027

The MTSAO 2022 considers potential levers in the pipeline for development from the promulgated IRP 2019 emerging plan. In general, judgement on the expected commercial operation dates of the IRP 2019 capacity is applied based on up-to-date information from the DMRE IPPO. The dates for all capacity from the emerging plan are adjusted accordingly, as shown in Table 2.

Table 2: IRP 2019: Bid Windows 5-8 installed capacity (MW)

Incremental capacity (MW)	*2022*	*2023*	*2024*	*2025*	*2026*	*2027*
PV			1 000	2 000		3 000
Wind			1 600	3 200	4 800	6 400
Battery					513	

4.8 Reserves

Table 3 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 2023-2027:

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 minutes reserve: This is generating capacity or demand-side managed load that can respond within 10 minutes when called upon. It may consist of a quick offline start generating plant (e.g., 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.

An assessment of the magnitude required for each reserve type (these reserves are mutually exclusive) is published annually (see Ancillary Services Technical Requirements report). The MTSAO 2022 includes these reserves and the individual generating units as well as the demand-side loads contributing to the total.

Table 3: Reserves requirement for seasonal peak and off-peak (FY2023-FY2027)

	Season	*2022/23*	*2023/24*	*2024/25*	*2025/26*	*2026/27*
Instantaneous	Summer/Winter	650	650	650	650	650
	Off-peak	850	850	850	850	850
Regulating	Summer/Winter	530	545	560	575	600
Ten-minute	Summer/Winter	1 020	1 005	990	975	950
	Off-Peak	820	805	790	775	750
Operating	Summer/Winter	**2 200**	**2 200**	**2 200**	**2 200**	**2 200**
Emergency		**1 400**	**1 300**	**1 200**	**1 100**	**1 000**
Supplemental		**200**	**300**	**400**	**500**	**600**

Table 4 shows 2021 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.

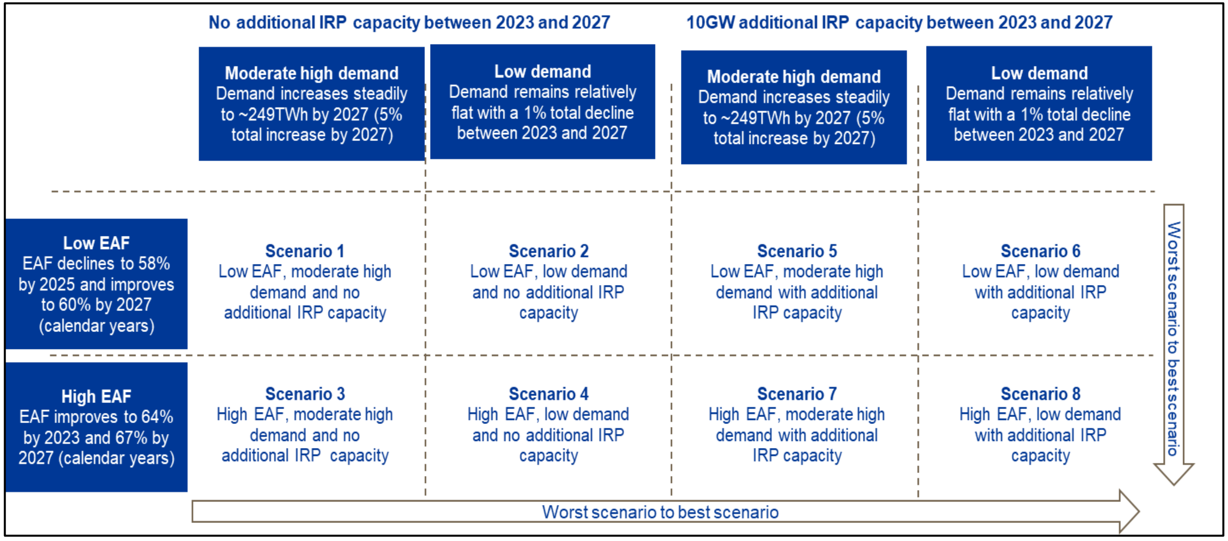
Table 4: 2021 frequency incidents

2021	*49,5 < f < 49,7*	*f < 49,5*	*f > 50,3*	*50,5 > f > 50,4*	*f > 50,5*
Jan	44	0	5	0	0
Feb	89	1	24	3	0
Mar	239	6	93	18	2
Apr	114	3	54	4	1
May	106	3	57	5	0
Jun	104	0	83	14	2
Jul	86	2	90	7	0
Aug	84	1	40	4	0
Sep	117	4	50	4	0
Oct	203	5	103	4	0
Nov	234	2	220	10	1
Dec	209	3	170	10	0

5. Study cases

The South African power system is sensitive to variations in the energy demand forecast and the Eskom fleet plant performance. The MTSAO 2022 considers four scenarios made of a combination of these parameters, as shown in Table 5. The low-demand forecast based on Eskom sales and the moderate-high demand forecast derived using GDP were both considered to assess the power system adequacy. The demand forecast scenarios are studied with low and high EAF scenarios to evaluate the adequacy of the power system. These four scenarios were each augmented with 10 GW of IRP 2019 capacity reflected in Table 2, expected between 2023 and 2027, producing eight total scenarios.

Table 5: MTSAO 2022 study cases



	No additional IRP capacity between 2023 and 2027		10GW additional IRP capacity between 2023 and 2027	
	Moderate high demand Demand increases steadily to ~249TWh by 2027 (5% total increase by 2027)	**Low demand** Demand remains relatively flat with a 1% total decline between 2023 and 2027	**Moderate high demand** Demand increases steadily to ~249TWh by 2027 (5% total increase by 2027)	**Low demand** Demand remains relatively flat with a 1% total decline between 2023 and 2027
Low EAF EAF declines to 58% by 2025 and improves to 60% by 2027 (calendar years)	**Scenario 1** Low EAF, moderate high demand and no additional IRP capacity	**Scenario 2** Low EAF, low demand and no additional IRP capacity	**Scenario 5** Low EAF, moderate high demand with additional IRP capacity	**Scenario 6** Low EAF, low demand with additional IRP capacity
High EAF EAF improves to 64% by 2023 and 67% by 2027 (calendar years)	**Scenario 3** High EAF, moderate high demand and no additional IRP capacity	**Scenario 4** High EAF, low demand and no additional IRP capacity	**Scenario 7** High EAF, moderate high demand with additional IRP capacity	**Scenario 8** High EAF, low demand with additional IRP capacity

6. Results

6.1 Adequacy metrics results of base case scenarios

Table 6 summarises the results averaged across the five-year MTSAO 2022 horizon and gives an overall adequacy status based on how the adequacy thresholds are satisfied or violated. The low EAF with low and moderate-high demand shows a system that remains inadequate throughout assessment. The system's inadequacy reduces with additional generation capacity (Kusile) in 2024, however, it worsens later. Improving the EAF to high shows reduced metrics violations compared to low EAF scenarios. The high EAF and low demand scenario shows marginal violation of the unserved energy metric and can be managed operationally by the SO.

Table 6: Adequacy metrics results without IRP 2019

	Contingency Baseload CF (%)	*OCGT CF (%)*	*Unserved Energy (GWh)*	*Overall Adequacy*
Low EAF, Moderate High Demand	59,7-68,3	37,11-59,9	2 894-10 877	🔴
Low EAF, Low Demand	52,2-62,.8	17,927	858-1 848	🔴
High EAF, Moderate High Demand	37,1-59,8	5,15-24,1	95,2-1 586	🔴
High EAF Low Demand	22,1-41,6	1,24-4,2	10,6-94,5	🟠

Table 7 shows that additional generation capacity from IRP 2019 Bid Windows 5 to 8 helps reduce system constraints but is insufficient to restore most of the scenarios to adequacy. This is particularly true for the low EAF and moderate-high demand scenarios that remain severely inadequate even with additional committed capacity, indicating a power system that is challenged to grow electricity consumption.

The IRP 2019 generation capacity has no impact on the year 2023 since the earliest MW are expected to be connected to the grid in 2024. The 2023 numbers across the different scenarios reflect the effect of EAF, which is the biggest lever available in the short term.

Table 7: Adequacy metric results with IRP 2019

	Contingency Baseload CF (%)	*OCGT CF (%)*	*Unserved Energy (GWh)*	*Overall Adequacy*
Low EAF, Mod-high Demand, IRP 2019	54,3-68,3	21,2-37,1	1 181-2 900	🔴
Low EAF, Low Demand, IRP 2019	33,4-62,8	4,5-23,3	77-1 186	🔴
High EAF, Mod-high Demand, IRP 2019	26,3-54,2	2-10,1	29,4-298	🟡
high EAF, Low Demand, IRP 2019	9,3-41,6	0,5-4,3	1,4-80	🟢

6.2 Energy gap requirements

The energy gap requirements refer to the additional energy needed on the system to restore system adequacy. Table 8 indicates the results of the analysis without additional IRP 2019 capacity. This type of energy is, for the most part, dispatchable and 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.

Table 8: Energy gap results with no additional IRP 2019 capacity (GWh)

	2023	*2024*	*2025*	*2026*	*2027*
Low EAF, mod-high demand	18 088	15 413	18 441	21 265	30 057
Low EAF, low demand	10 483	5 858	5 922	5 425	9 867
High EAF, mod-high demand	2 851	75	223	2 059	9 597

The results show an energy shortfall of 18 TWh for the worst-case scenario in the year 2023. This energy is equivalent to the Matla[1] Power Station operating at full load, performing at the current trend. The energy gap reduces to 15 TWh with the addition of Kusile capacity and steadily increases to 30 TWh because of some plants shutting down. The high EAF with moderate-high demand shows that less energy will be needed to restore the system to adequacy when the system EAF improves from an average of 58% to 67%. It shows that an

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[1] Matla is a coal-fired power station owned by Eskom, with a sent-out capacity of 3 450 MW.

improvement in EAF provides more energy to support higher electricity growth with quicker turnaround times.

Table 9 shows the results of the energy gap analysis when a total of 10 GW of IRP 2019 BW5 to 8 by 2027 is added.

Table 9: Energy gap results with additional IRP 2019 capacity

	2023	*2024*	*2025*	*2026*	*2027*
Low EAF, mod-high demand, IRP 2019	18 087	9 091	7 022	6 679	7 959
Low EAF, low demand, IRP 2019	10 483	2 266	711	300	331
High EAF, mod-high demand, IRP 2019	2 851	0	44	127	243

7. Sensitivities

While the study cases of section 6 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

IRP 2019 acknowledged that as Koeberg Nuclear Power Station reaches the end of its design life in 2024, however, to avoid the demise 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).

The MTSAO 2022 considers the impact of possible delays of Koeberg's life extension by two years, based on recent developments, resulting in a loss of 1 860 MW or up to 15 TWh per year. The results in Table 10 show a system that is severely constrained with the potential shutdown of Koeberg Unit 1 in July 2024 and Unit 2 in November 2025 in accordance with the Koeberg 40-year life of plant.

Table 10: Koeberg risk with no additional capacity

	Contingency Baseload CF (%)	*OCGT CF (%)*	*Unserved Energy (GWh)*	*Overall Adequacy*
Low EAF Mod-High Demand + Koeberg Risk	59,8–68,3	37-63	2 899–12 606	●
Low EAF Low Demand + Koeberg Risk	52,5–62,8	21-32	1 025–2 470	●
High EAF Mod-High Demand + Koeberg Risk	38,2–61,3	5,7–28,1	104–2 079	●
High EAF Low Demand + Koeberg Risk	23,2–41,6	1,7–5,3	14-131	●

7.2 Minimum emissions standards

In terms of the National Environmental Management: Air Quality Act, 2004 (Act No. 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 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 is 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.

- ✓ 15,9 GW immediately upon implementation of the MES decision; and
- ✓ 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 for the country’s needs. 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[2] at Parliament to constitute an appeals forum. A forum named the National Environmental and Consultative Advisory (NECA) was nominated and subsequently appointed[3] to oversee a public participation process to assess, review, and report to the Minister on the impact of the decision, taking into account the air quality, public health, and the 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, 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

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[2] https://www.parliament.gov.za/storage/app/media/Docs/atc/bf3f6a83-4fd2-41b7-8454-5e49c13504ab.pdf

[3] Government Gazette No. 46746

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 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 these options would have on electricity supply and the stability of the grid. Further, the forum is tasked to consider the Minister's constitutional and legislative mandate and the country's international commitments, the health and well-being of people, the energy crisis, and the local economic climate.

Eskom and other interested and affected parties were invited to contribute to technical briefings hosted by the forum. The focus is to outline 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 is expected to hold public stakeholder meetings with affected communities in November 2022 and submit its recommendations to the Minister of the DFFE by February 2023

8. Potential levers to close the supply shortfall not considered

The MTSAO 2022 notes developments in the electricity supply industry pertaining to initiatives earmarked to mitigate against current power system constraints. The options identified that may be achieved within the study period include the following:

- ✓ Improvement of the system EAF
- ✓ Improvement of new build performance to design levels
- ✓ Expediting the roll-out of new capacity
- ✓ Exemption of licence initiatives
- ✓ Leasing of Eskom land initiatives
- ✓ Demand-side management initiatives

However, because of challenges in obtaining validated data for any of these initiatives, none are considered in the MTSAO 2022. For this reason, the impact of only committed capacity of the IRP 2019 Bid Windows is assessed.

8.1 Small-scale embedded generation (SSEG)

On 10 June 2021, President Cyril Ramaphosa announced that the embedded generation threshold would be allowed to increase from 1 MW to 100 MW. This announcement was seen as having a positive impact on improved investment in embedded generation projects. The DMRE has therefore increased the SSEG threshold from < 1 MW per site to a maximum of < 100 MW per individual site. In response to this important change in policy, NERSA received applications for 758 MW of SSEG capacity from the commercial and industrial sectors from 1 January 2022 to 31 August 2022. According to the GreenCape 2022 Market Intelligence report, the annual available market of rooftop PV is estimated to continue to grow at a rate of 250-400 MW installed per year, reaching a total of 7,5 GW by 2035. The current South African SSEG market is dominated by rooftop solar PV because of viable prices, technology maturity, and affluence of implementation of solar panels, and this trend is expected to persist.

The Solar Show Africa (24 August, Sandton Convention Centre) affirms that SSEG growth of 250-400 MW year on year is very conservative, whereas their forecasts are much higher for the period 2023 to 2035. Engagements with PV panel manufacturers and installers at the show estimate SSEG growth as high as 1 500 MW per annum

Collation of this information as to how this would unfold going forward has proven a challenge following numerous attempts made with relevant stakeholders such as NERSA, DMRE, CSIR, BUSA, SAPVIA, and EUIG. However, the EIUG (Energy Intensive User Group) pledged investments that could bring the less than 100 MW initiatives with a focus on addressing the immediate electricity supply shortfall and ending load shedding. Possibly, as much as 5 200 MW could be realised during the MTSAO planning horizon.

8.2 National energy crisis committee initiatives

Following the Nation’s address by President Cyril Ramaphosa on 25 July 2022, where he announced an intervention to end load shedding and achieve energy security, the President also announced the lifting of the licensing of the <100 MW threshold. The NECOM, comprising all government departments, Eskom, research institutions, and other public entities, was then established to co-ordinate a response to the current energy crisis to end load shedding.

The NATJOINTS, in support of NECOM, identified the following initiatives and focus areas to achieve this objective:

- ✓ improving the performance and availability of the existing Eskom plant;

- ✓ expediting the connection of generation capacity from existing and future procurement rounds, as well as on measures to enable private investment and facilitate SSEG;
- ✓ developing a detailed plan to improve demand management and ensure the implementation of energy efficiency and customer response measures; and
- ✓ procuring power from companies who have existing generation capacity through Eskom's Standard Offer Programme. The combined programme is predicted to exceed 1 000 MW.

Through the NECOM initiatives, procurement of the IRP 2019 capacity will be accelerated, with Bid Window 6 allocated capacity doubling from the initial 2 600 MW to 5 200 MW. Capacity of 3 000 MW from gas and 513 MW from battery would also be procured in the next bid windows.

Even before the announcement of the lifting of licensing of the <100 MW initiatives, there was a huge interest with a potential of adding over 6 000 MW of variable renewable and other technologies comprising solar PV, hybrid, wind, diesel, and biomass from the private sector.

Eskom has released land adjacent to its existing power stations in Mpumalanga for private investment in renewable energy projects, which will unlock 2 000 MW of new capacity. This will have the added benefit of eliminating the grid availability constraint.

9. Conclusions and recommendations

South Africa has been faced with chronic power supply constraints for over 10 years. The current year has been the worst yet, and it is evident from this study that the situation will worsen as the plant performance of Eskom's fleet continue to trend downwards, power stations shut down, and demand grows.

The result of this MTSAO showed the following:

- ✓ The low EAF scenario is severely inadequate irrespective of the demand forecast scenarios.
- ✓ The high EAF scenarios are just about adequate only in the low-demand scenario, which does not support a higher economic growth rate.
- ✓ The high EAF and the moderate-high demand scenario are likewise inadequate.

Traditionally, new capacity will need to be procured through a section 34 determination process to improve the security of supply and set the country's power system on a path to recovery and growth. Typically, this is a prolonged process, and the outcomes of this study show that the envisaged new capacity in the IRP 2019 emerging plan when completely rolled out, will not be enough to fully remedy the supply constraints.

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 MTSAO 2022 study shows that delays to the extension of the operating licence of Koeberg will further exacerbate the power supply constraints leading to massive amounts of unserved energy. Although not assessed in detail, it can be concluded that enforcing the MES regulations will be catastrophic to the operability of the power system, given the quantum of capacity impacted by the MES decision.

To restore power system adequacy in the medium term, the MTSAO 2022 recommends the following:

- ✓ The MTSAO 2020 had reported that Eskom initiated a Generation Reliability Maintenance Recovery Programme (RMR) with an objective of doing deep refurbishment and maintenance requirements to improve the system EAF. However, evidence as seen in Figure 4 shows a trend of outages that continue to increase, thereby decreasing system EAF. This suggests that the RMR programme in its current form may not be yielding desired outcomes. Given that the EAF is the biggest lever to system adequacy and the statistically determined trend reflects a further downward trajectory, it is crucial that the current maintenance regime is reviewed to improve its efficacy.

- ✓ It is no longer a matter of expediting new generation capacity based on the IRP 2019, recent studies such as Eskom Transmission's Generation Connection Capacity Assessment 2024[4] (GCCA 2024) report notes 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". It concludes that the IRP 2019 capacity in its current form cannot be connected in those areas in the medium-term. Therefore, transmission development projects need to be expedited to unlock potential generation initiatives.
- ✓ Ensure that compliance with the MES does not result in a capacity shutdown.
- ✓ Ensure that there are no further delays in the commissioning of the Eskom new build programme and that the process to address design defects at Medupi and Kusile does not just continue promptly but also yields improved performance.
- ✓ Place more emphasis on extending the life of Koeberg Power Station, as the loss of Koeberg units would significantly impact adequacy in the short term.

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[4] The GCCA report provides readily accessible information on where and how much generation connection capacity is available within the transmission network and can be accessed at https://www.eskom.co.za/eskom-divisions/tx/gcca/

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