Medium-term System Adequacy Outlook 2017 to 2022

30 October 2017

Contents

List of Tables

List of figures

Overview

The South African Grid Code – System Operation Code, Version 9.0, requires that “on or before 30 October of each year, the System Operator shall publish a review (called the ‘Medium Term System Adequacy Outlook’) of the adequacy of the Interconnected Power System (IPS) to meet the long term (5 year future) requirements of electricity consumers”. This review is limited to the adequacy of the generation system for the Republic of South Africa.

1 Introduction

The Medium-term System Adequacy Outlook (MTSAO) provides a statement of generation adequacy to meet the expected electricity demand for the next five years (calendar years 2017 to 2022), made up of a combination of local consumption and exports. This demand is satisfied by a combination of all generation resources licensed by NERSA, imports, and demand-side management resources. The adequacy to transmit and distribute electricity does not form part of this MTSAO.

2 Methodology and approach

The South African IPS is assessed based on the system adequacy metrics, as shown in Table 1 below. The adequacy metrics are chosen to provide information on the operational capacity and energy adequacy of the generation system to meet expected demand. The threshold for each of the metrics is set at the point of least total cost to the consumer.

Table 1: Adequacy metrics

	Adequacy Metric	Threshold	Details
Capacity Adequacy	Unserved Energy	<20GWh per annum	Energy not supplied
	OCCGT Load Factor	<1% per annum	Gross load factor of all OCGT plant
	Emergency Level 1	<133GWh per annum	Energy supplied by generators operating above their continuous rating
Energy Adequa	Expensive Base Load Stations	<50% per annum	Gross load factor of the expensive coal-fired base-load stations

The MTSAO uses a stochastic model to dispatch all available generation resources to meet demand on an hourly basis. The demand is randomly scaled up and down while supply is varied through a maintenance distribution that mimics reduction in capacity due to outages. The results of the MTSAO are based on the average outcome.

The system is deemed adequate only if all system adequacy metrics in Table 1 above are satisfied. Should any of the adequacy metrics not be met, additional resources are added until the adequacy metrics are met, as shown in Figure 1. The mitigation options, added to get an adequate system, are quantified in terms of base-load, mid-merit, and peaking capacity in MW.

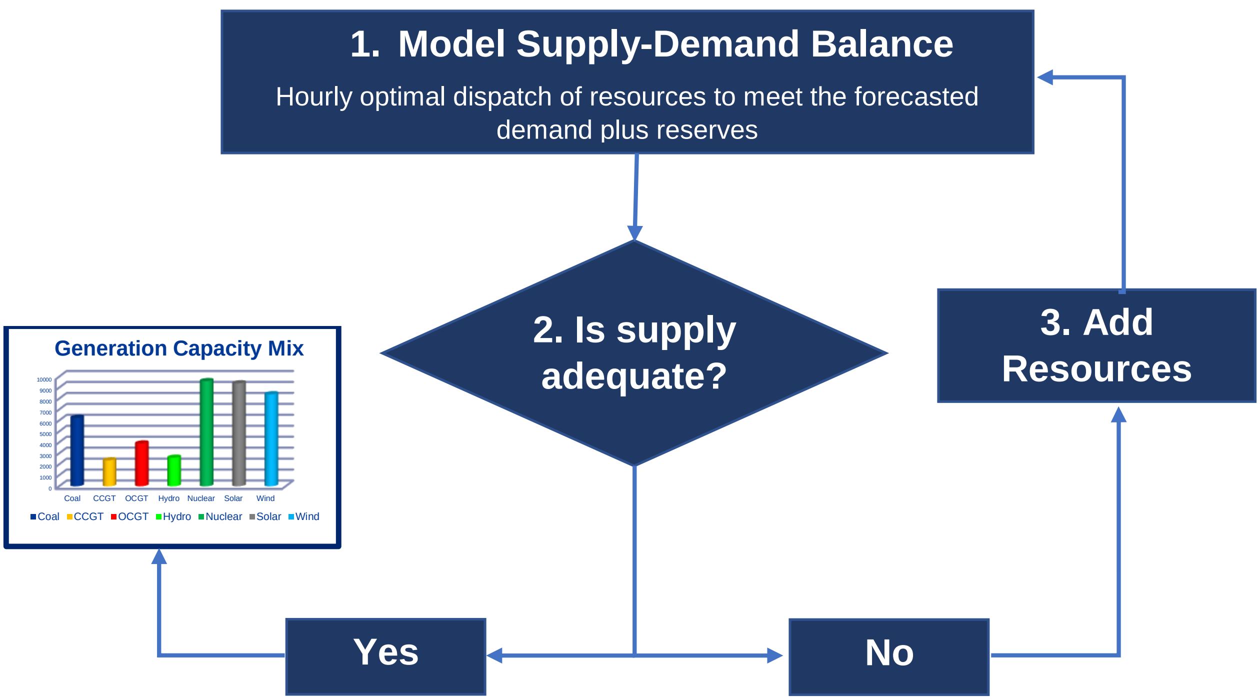

Figure 1: MTSAO methodology

In the event that the system is adequate, the plant that is in excess to that required for an adequate system is quantified. The excess plant is determined each year by excluding a base-load plant of average availability and reiteratively testing for adequacy until the point where the matrix is violated, while ensuring that sufficient reserves are maintained.

3 Assumptions

Key planning assumptions are demand forecast, existing and committed supply resources, and plant performance.

3.1 Demand forecast

Two country-level demand forecasts were developed internally in Eskom: the moderate growth demand forecast and the low demand forecast, shown in Figure 2 and Table 2 below. The base case is the moderate forecast, with a compounded average growth rate (CAGR) of 2.0%. This forecast takes account of current economic conditions, and forecasts increase in demand as a result of Eskom's drive to increase sales both locally and across the border. The low forecast has a CAGR of 0.4% and is based on the April 2016 published MTSAO that reflects lower than anticipated growth.

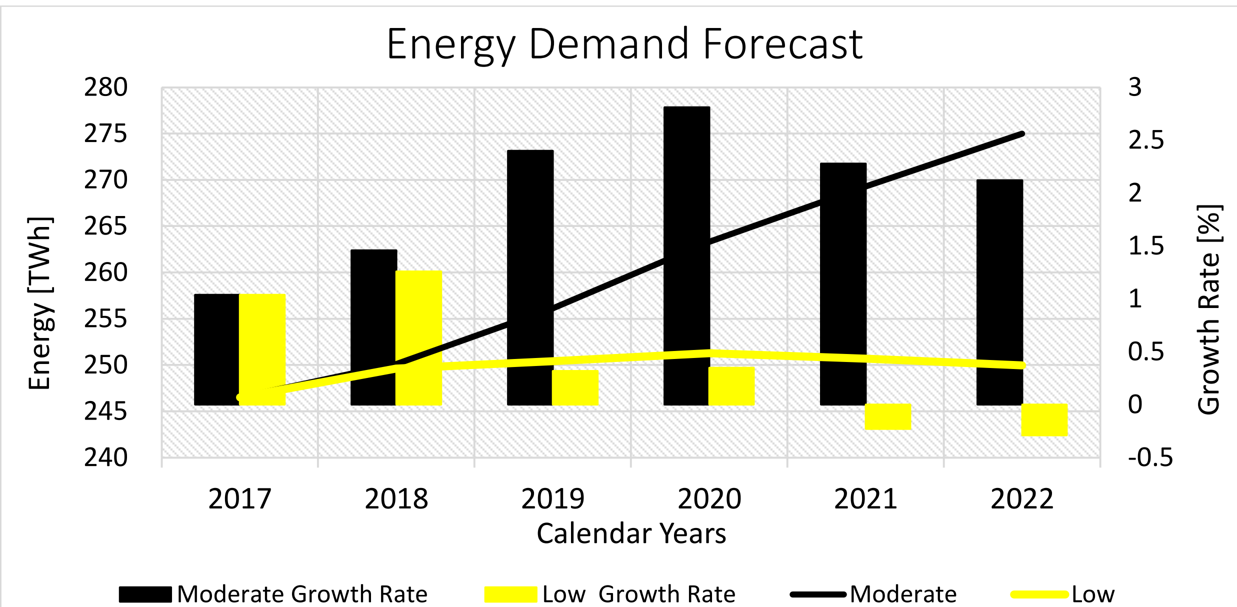

Figure 2: Energy demand forecasts

Table 2: Energy demand forecast comparison in GWh

	Moderate growth	Low growth
2017	246 500	248 607
2018	250 100	251 730
2019	256 100	252 532
2020	263 300	253 416
2021	269 300	252 826
2022	275 008	249 976

3.2 Existing and committed supply resources

Generation resources and demand-side initiatives are both used to meet the forecast demand. The capacities of the generation resources are, furthermore, grouped in terms of Eskom installed capacity, Eskom new build commercial operation dates, non-Eskom capacity without the Renewable Energy Independent Power Producer Program (REIPPP), and REIPPP capacity.

3.2.1 Existing Eskom installed capacity

The total Eskom installed capacity consists of coal, nuclear, pumped storage, diesel, hydro, and wind. Table 3 depicts the existing Eskom installed capacity over the study horizon, but excludes Medupi and Kusile which are shown in Table 4 below.

Table 3: Eskom installed capacity

	2017	2018	2019	2020	2021	2022
Coal	35795	35795	35795	35238	34307	33565
Nuclear	1860	1860	1860	1860	1860	1860
Pumped storage	2724	2724	2724	2724	2724	2724
Diesel	2409	2409	2409	2409	2409	2409
Hydro	600	600	600	600	600	600
Wind	100	100	100	100	100	100
	43,488	**43,488**	**43,488**	**42,931**	**42,000**	**41,258**

In line with Integrated Resource Plan (IRP) 2010, the existing Eskom coal-fired power stations were modelled with a 50 year life of plant (LOP). Table 4 shows capacity of plants reaching 50 years during the study horizon.

Table 4: Capacity reaching 50 years

	2017	2018	2019	2020	2021	2022
Arnot	2,232	2,232	2,232	2,232	1,860	1,860
Hendrina	1,870	1,870	1,870	1,683	1,309	1,122
Camden	1,480	1,480	1,480	1,110	925	370

3.2.2 Eskom new build commercial operation dates

The official commercial operation dates (CoDs) for Medupi and Kusile are depicted in Table 5 below. The current construction performance of new committed generated capacity has resulted in earlier than previously assumed commercial operation of the full Ingula station, Medupi's Unit 5 & 6 as well as Kusile unit 1.

Table 5: Commercial operation dates for Eskom new build

MEDUPI		KUSILE	
Unit 6	Commercial	**Unit 1**	Commercial
Unit 5	Commercial	**Unit 2**	2019-Apr
Unit 4	2017-Dec	**Unit 3**	2020-May
Unit 3	2019-Jun	**Unit 4**	2021-Mar
Unit 2	2019-Dec	**Unit 5**	2021-Nov
Unit 1	2020-May	**Unit 6**	2022-Sep

3.2.3 Non-Eskom capacity without the REIPPP

Table 6 depicts the non-Eskom and cross-border import capacities assumed in the study, based on the latest Eskom and NERSA information.

Table 6: Non-Eskom supply sources, including imports (MW)

	2017	2018	2019	2020	2021	2022
Kelvin	160	160	-	-	-	-
Sasol Infrachem coal	125	125	-	-	-	-
Sasol Synfuel coal	600	600	600	600	600	600
DoE Peaker	1,005	1,005	1,005	1,005	1,005	1,005
Other gas	140	140	140	-	-	-
Sasol Infrachem gas	175	175	175	175	175	175
Sasol Synfuel gas	250	250	250	250	250	250
Cahora Bassa	1,548	1,548	1,548	1,548	1,548	1,548
Mondi	144	144	144	144	144	144
Other cogeneration	140	140	140	140	140	140
Other hydro	12	12	12	12	12	12
Other wind	5	5	5	5	5	5
Sappi Ngodwana	174	174	174	174	174	174
Steenbras	180	180	180	180	180	180
Colley Wobbles	65	65	65	65	65	65

3.2.4 Renewable Energy Independent Power Producer Program

Table 7 below shows the installed capacity of Renewable Energy Independent Power Producers (REIPP) that is considered committed in this MTSAO. It includes projects from Bid Windows 1 to 3.5, excluding the 100 MW of CSP not yet signed from Bid Window 3.5.

Table 7: REIPPP committed capacity

	2017	2018	2019	2020	2021	2022
Wind	1,470	1,982	1,982	1,982	1,982	1,982
PV	1,474	1,474	1,474	1,474	1,474	1,474
CSP	200	300	500	500	500	500
Landfill	11	13	13	13	13	13
Hydro	14	14	14	14	14	14
Biomass	-	17	17	17	17	17
	3,169	**3,800**	**4,000**	**4,000**	**4,000**	**4,000**

In light of outputs of the July 2017 MTSAO showing a surplus capacity for a moderate forecast, this study further determines the additional surplus as a result of connecting additional REIPPs. The additional REIPP capacities, as shown in Table 8 include a second 100MW CSP plant from Bid Window 3.5 and all projects from Bid Window 4 and exclude Eskom CSP. These projects were phased by one year from the publicly communicated dates to allow for delays in contract closure.

Table 8: REIPPP additional capacity

	2017	2018	2019	2020	2021	2022
Wind	-	9	607	1,264	1,264	1,372
PV	-	145	618	843	843	843
CSP	-	-	100	100	100	100
Landfill	-	-	-	-	-	-
Hydro	-	5	5	5	5	5
Biomass	-	30	35	35	35	35
	-	**189**	**1,365**	**2,247**	**2,247**	**2,354**

3.3 Eskom plant performance

The plant performance that was considered in this study is depicted in Figure 3, showing an energy availability factor (EAF) that recovers to 80% as early as 2020 and is maintained beyond the study horizon.

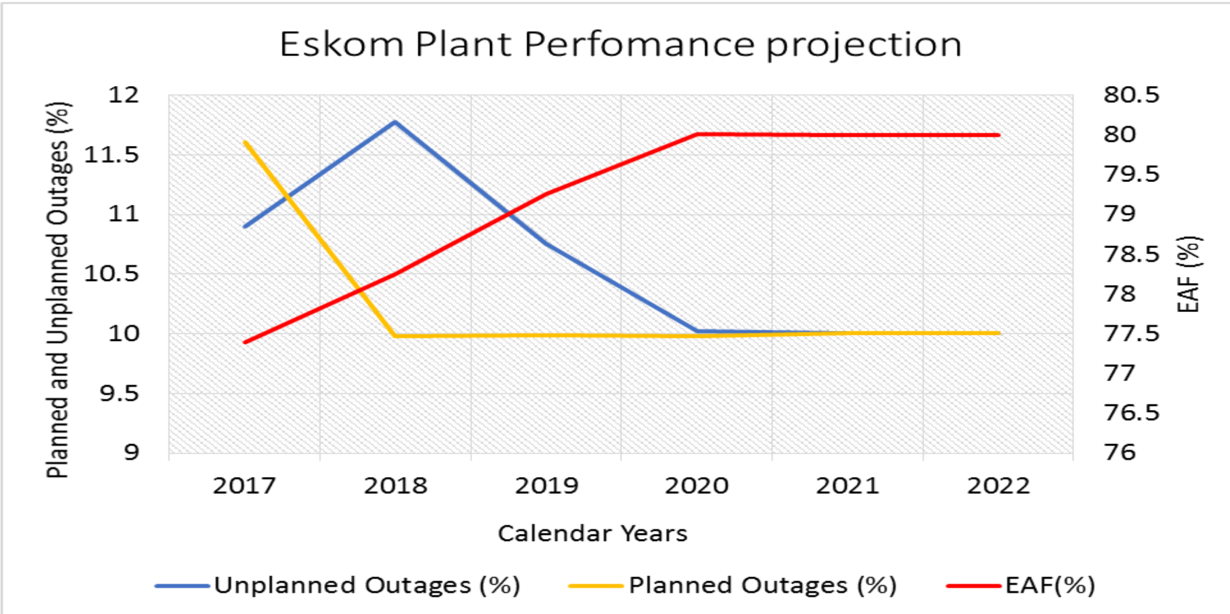

Figure 3: Plant performance forecast of Eskom fleet

4 Scenarios

The scenarios considered in this study are shown in Figure 4 below. Common parameters are the 50-year life of plant for coal power stations, the official CoD for Eskom new build plants, and Eskom plant performance. Two demand forecasts were tested: a moderate growth demand forecast and a low growth demand forecast, as depicted in Figure 2 above. For each forecast, a scenario where only contracted REIPP projects are connected to the grid was compared with that when additional REIPP projects are connected, as listed in Table 7 and Table 8 above.

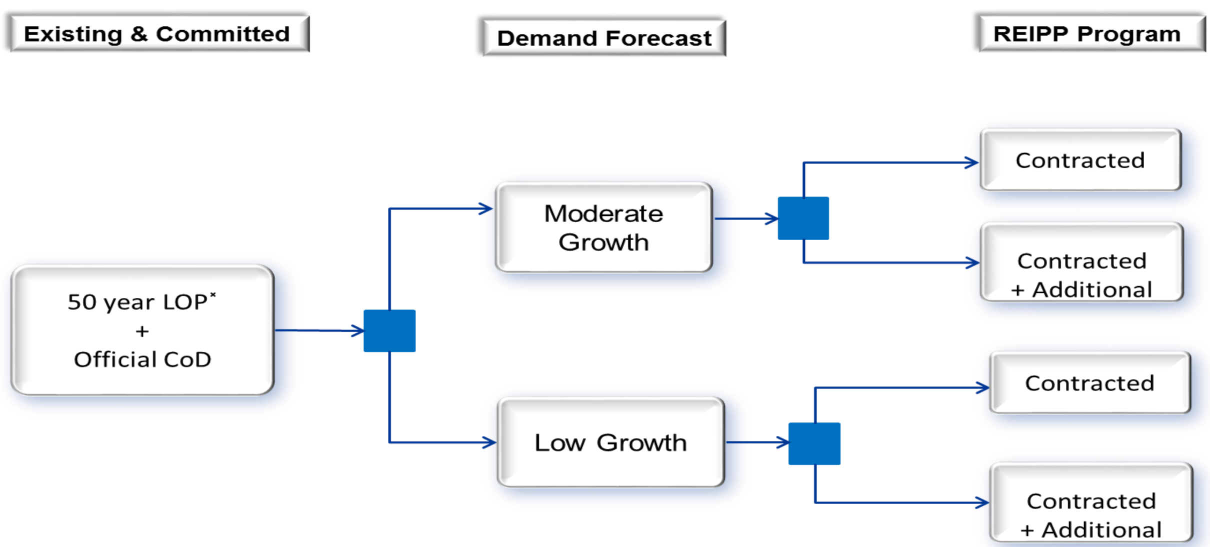

Figure 4: Scenarios considered

Scenarios not considered include the risks of inadequate coal stock levels at multiple power stations and drought in the Western Cape, which have been identified in the short term, since they have treatment plans and are managed.

5 Results

The results of the study show that excess capacity exists in the study horizon for all the scenarios tested as shown in Figure 5 below. Comparable results are seen in 2017 and 2018 for all scenarios, since the forecasts start off similar, while only a small capacity of additional REIPP is added in 2018. From 2019, the excess capacity in the low demand forecast scenarios increase more than the moderate demand forecast scenarios due to the lower demand. The addition of more capacity also increases the excess capacity over the study period. In all scenarios, the plant reaching 50-year life from 2020 offsets surplus capacity that results from connecting new build plants and REIPP projects.

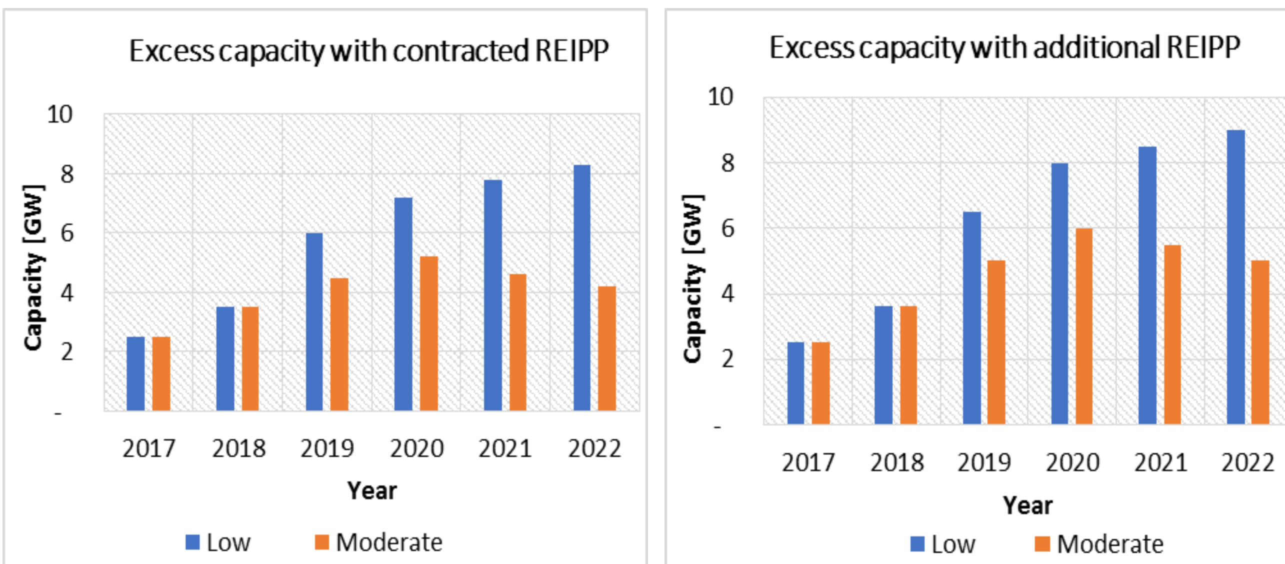

Figure 5: Results of considered scenarios

To illustrate the effect of intermittent plant on the system, the residual load for low and moderate forecasts is shown in Figure 6 for 2018 and Figure 7 for 2022. Residual load is the remaining load left after subtracting hourly dispatch of intermittent plant; this load is supplied by dispatchable plants such as coal, nuclear and gas. The current level of intermittent plant does not have a significant impact on the adequacy of the system, as shown in Figure 7.

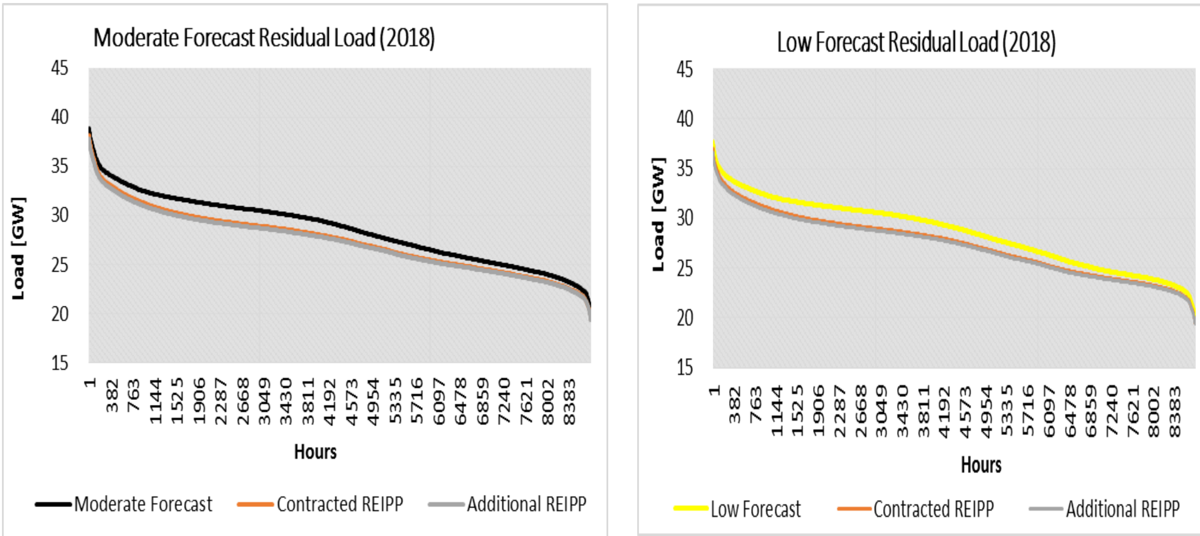

Figure 6: Residual load for considered forecasts in 2018

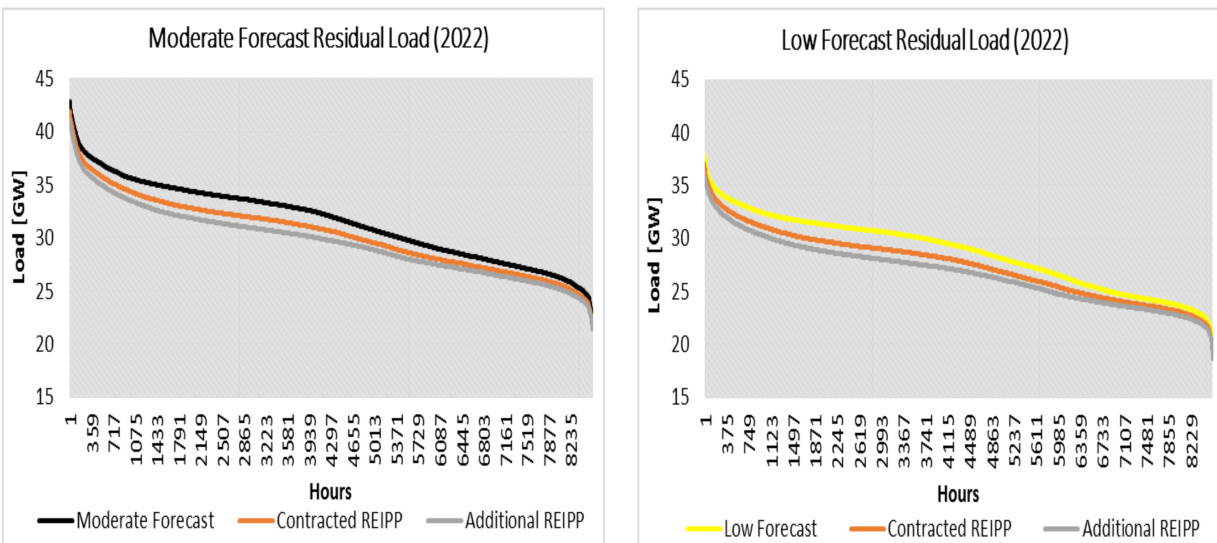

Figure 7: Residual load for considered forecasts in 2022

The energy utilization factor (EUF) of the Eskom coal fleet on different scenarios is shown in Figure 8 below. The results show that increases in capacity lowers the EUF while increasing the demand raises the EUF.

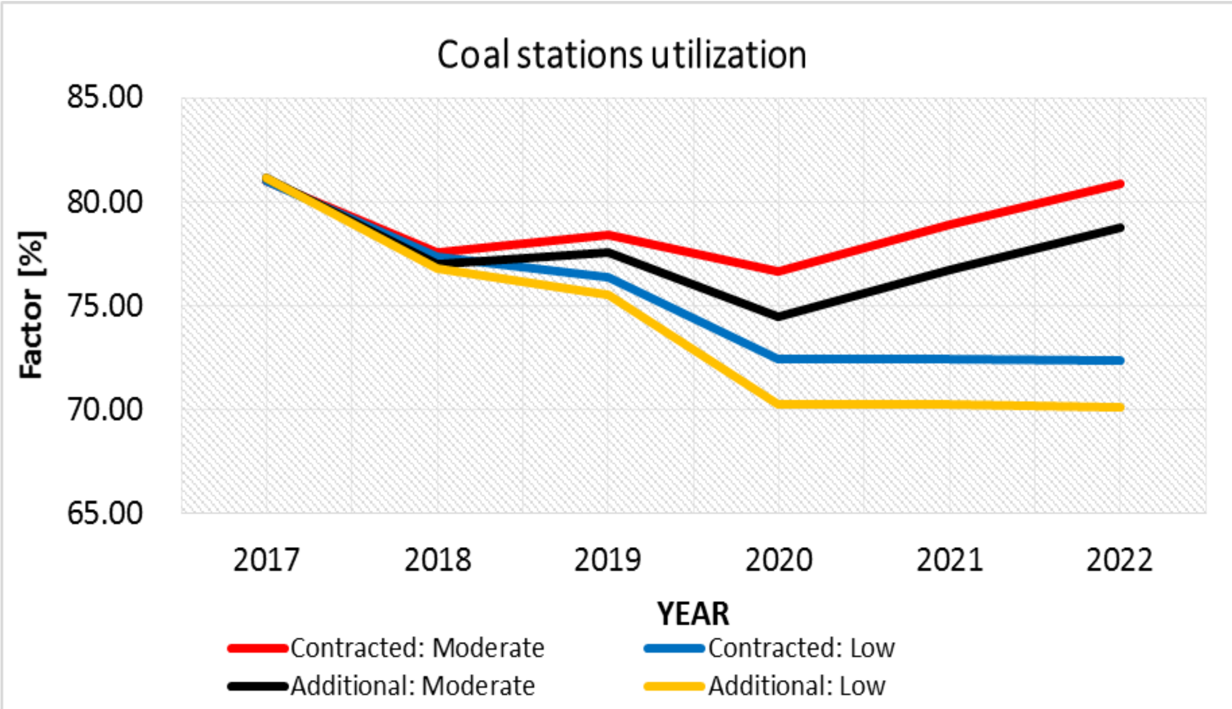

Figure 8: Eskom coal energy utilisation factor

6 Conclusion

The October 2017 MTSAO study shows that the system is adequate in the short- to medium-term to meet demand from 2017 to 2022 in all the scenarios studied. The study further shows that the system has excess capacity in all the scenarios studied in the study horizon.

The excess capacity is the highest in the low demand with additional capacity. Although additional capacity from Eskom new builds and REIPP projects is connected to the grid in the study horizon, the magnitude of excess capacity in the later years of the study is offset by plants that reach 50-year life.

The excess capacity in the short- to medium-term provides Eskom with opportunities to target increasing electricity sales locally and cross-border.

7 Appendix: System Operator Statistics

Although the MTSAO traditionally assesses system adequacy, the modern power system dynamics that are a result of increased penetration of intermittent plants call for increased monitoring of system reliability. To provide more information on system reliability, the statistics are shown below (actual System Operator year-to-date data as at end September 2017):

a. The open cycle gas turbine (OCGT) load factor includes Ankerlig (1 327 MW), Gourikwa (740 MW) and Department of Energy (DoE) OCGTs at Dedisa (335 MW) and Avon (670 MW). The contractual load factor the DoE OCGTs is 1%

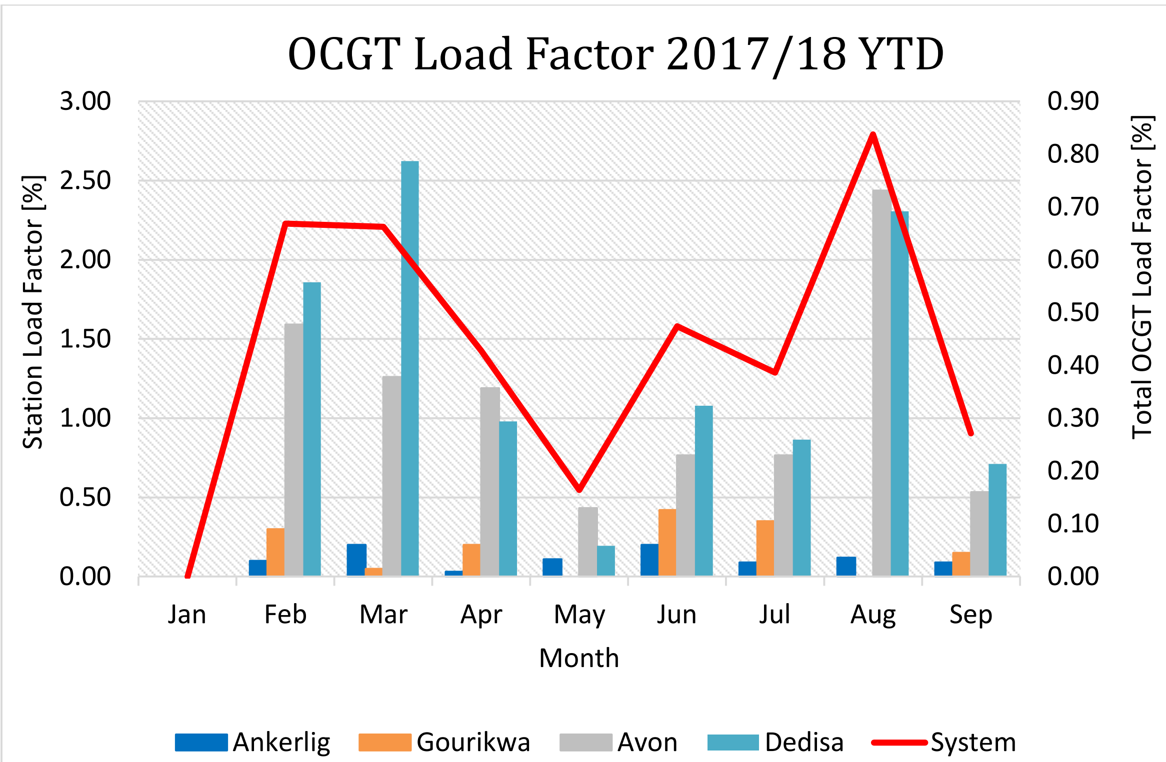

Figure 9: Year-to-date OCGT utilisation

The year to date statistics in Figure 9 show a weighted total OCGT utilisation that is well below 1%, even when meeting the DoE OCGTs load factor.

b. Frequency incidents reveal cases where reserves were deployed. Paragraph 9 of the South African Grid Code: Version 9 stipulates the type (instantaneous, regulating) and capacity in MW required to restore the system depending on the level of frequency drop. The actual incidents in Figure 10 below show that the system had sufficient reserves to recover from the disturbances. There were no incidences of frequency dropping less than 49.2Hz; such an incident would automatically activate under-frequency load shedding.

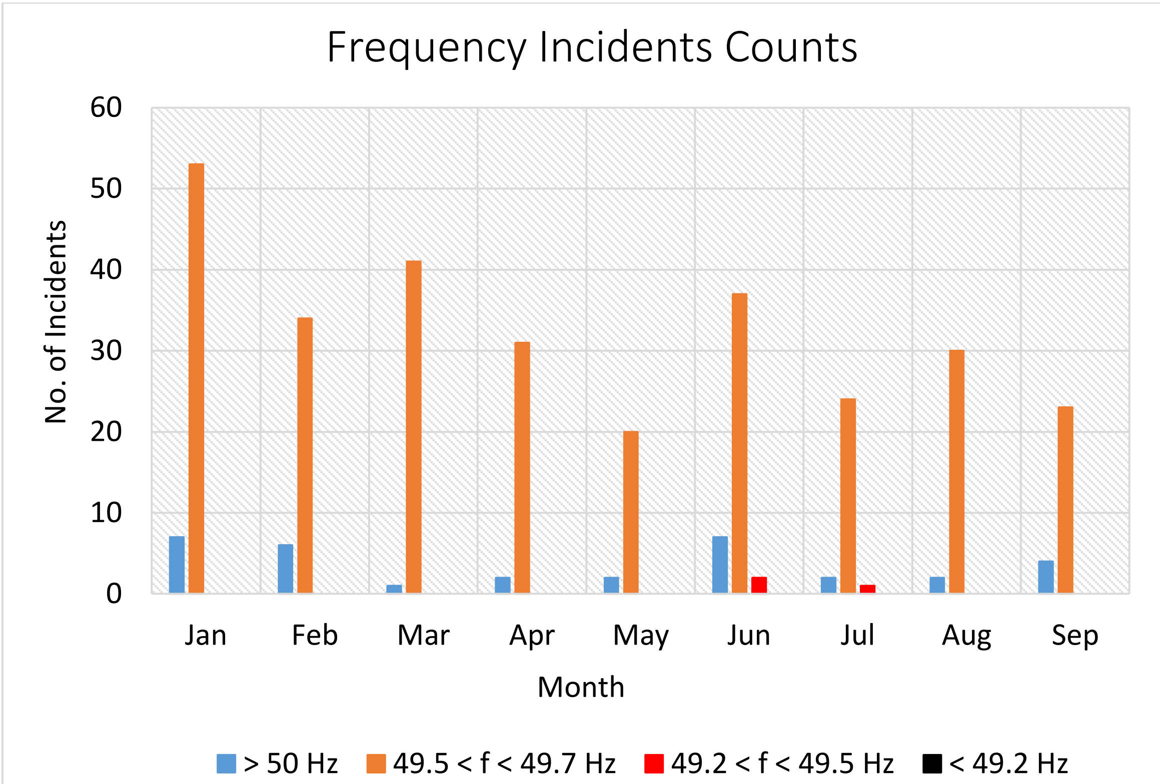

Figure 10: Number of frequency incidents

8 Glossary and abbreviations

"**Adequacy**" relates to the existence of sufficient facilities in the system to satisfy the customer load demand or system operational constraints. Adequacy is, therefore, associated with static conditions, which do not include system dynamic and transient disturbances.

"**Adequacy metrics**" are the output parameters analysed to determine "adequacy".

"**Base load**" represents plant capable of generating all day.

"**CAGR**" means compounded average growth rate.

"**CoD**" means commercial operation date.

"**CSP**" means concentrated solar power.

"**EAF**" means energy availability factor and reflects a unit, plant, or industry's availability to produce energy. The energy availability factor is the ratio of available energy over the nominal energy (sent-out energy capability) and refers to the energy that could have been produced at available capacity for the reference period over the nominal energy for the same period.

"**EUF**" means energy utilisation factor that measures of the degree to which the available energy capacity of an electricity supply network is utilised. It reflects the ratio of actual energy produced against the energy that the full available capacity could have produced.

"**Non-Eskom capacity**" means generation capacity from external sources.

"**IPP**" means independent power producer.

"**Load factor**" reflects the ratio of the actual generated energy against the nominal energy (sent-out energy capability) and, thus, represents the extent to which the installed capacity is utilised. The calculation method of this measure is similar to the term "capacity factor", which is used in certain electricity generating references.

"**LOP**" means life of plant.

"**Mid-merit**" represents plant typically generating from before the morning peak demand to after the evening peak demand.

"**NERSA**" means National Energy Regulator of South Africa.

"**Peaking**" represents plant generating only during the peak demand or emergency hours.

"**PV**" means solar photovoltaic.

"**REIPPP(s)**" means Renewable Energy Independent Power Producer Programme(s).

"**SO**" refers to the System Operator who is responsible for dispatch of power.