SYSTEM OPERATOR

Ancillary Services Technical Requirements for 2021/22 – 2025/26

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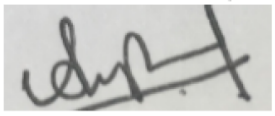		
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ANCILLARY SERVICES TECHNICAL REQUIREMENTS FOR 2021/22 – 2025/26

1. INTRODUCTION

This document specifies the technical requirements for ancillary services for the financial year period 2021/22 till 2025/26. Its purpose is to make known the technical requirements of the System Operator with respect to ancillary services. The technical requirements as specified in this document will be used to develop a medium term view of requirements for ancillary services in the 5-year time horizon, and to contract for the forthcoming financial year, 2021/22.

The following requirements are defined as ancillary services:

- Reserves
- Black Start
- Unit Islanding
- Reactive Power Supply and Voltage Control
- Constrained Generation

2. METHODOLOGY

The methodologies on which the 2021/22 – 2025/26 ancillary services technical requirements are based are captured in the Ancillary services technical requirements methodologies document [1].

3. RESERVES

3.1 INTRODUCTION

The definitions of the five reserve categories included in ancillary services are given in the Glossary of Reserve Related Terms [2] document and the South African Grid Code [3]. The minimum requirement for each reserve category is revised annually. Each reserve category has its own requirement and is exclusive, that is capacity reserved for one category cannot be used for another category. National Control will dispatch reserves according to the scheduling and dispatch rules as far as possible while adhering to the relevant guideline [5].

3.2 INSTANTANEOUS RESERVE

3.2.1 Description

Instantaneous reserve 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. It is needed to arrest the frequency at an acceptable level following a contingency, such as a generator trip, or a sudden surge in load. Generators contracted for instantaneous reserve are also expected to respond to high frequencies (above 50.15 Hz) as stipulated in the South African Grid Code.

3.2.2 Technical Requirements

The Instantaneous reserve requirement was determined through a dynamic simulation study by establishing the effect of governing on system frequency [6]. The study considered various scenarios, which included various levels of generation and demand side capacity. Renewables (RE) were included in the study. Their impact was assessed during off peak periods, i.e. when demand was at its lowest, representing a low inertia scenario. RE impact is noticeable during off peak but overall the impact on reserves was not significant. The study results are valid for

2021/22 due to significantly high RE integration from 2022 as per 2019 IRP[4]. More studies will be conducted to validate requirements from 2022. The minimum requirements, which are based on only **generators providing instantaneous reserves**, are shown in

Table 1.

Table 1: Instantaneous reserve requirements

Season	Period	2021/22 MW	2022/23 MW	2023/24 MW	2024/25 MW	2025/26 MW
Summer/ Winter	Peak	650	650	650	650	650
	Off peak	850	850	850	850	850

The study has indicated that less instantaneous reserve is required over peak periods, due to higher system inertia during peak compared to off peak. Instantaneous reserve can also be provided by loads i.e. demand response. The optimum split between generators and loads, based on the dynamic study conducted by SO [6], is as follows:

Peak periods		Off peak periods		Reserve provider
Generators MW	Demand Response MW	Generators MW	Demand Response MW	
650	0	850	0	Generators only
600	200	800	200	Generators and loads
550	400	750	400	Generators and loads
500	600	700	600	Generators and loads
450	800	650	800	Generators and loads
400	1000	600	1000	Generators and loads

3.3 REGULATING RESERVE

3.3.1 Description

Regulating reserve 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 scheduled frequency and keep tie line flows between control areas within schedule.

3.3.2 Technical Requirements

The IPS needs sufficient regulating range up and down every hour of the day to keep the frequency and tie line flows within schedule while meeting the peak load within the peak hour. The optimum regulating up and down reserve requirement is based on catering for variability of load and renewables for 95% of the time and also compliance with SAPP CPS performance criterion requirements.

A) Variability study

The purpose of this study was to determine the minimum regulating reserve capacity to ensure that load and renewables variability do not compromise frequency control requirements. A production simulation study was undertaken to determine the optimum reserve capacity. Various demand and generation performance scenarios were considered i.e. Low demand low performance, moderate demand moderate performance, high demand high performance. Figure 1 below depicts simulation results for 2021 and Figure 2 depicts simulation results for 2025.

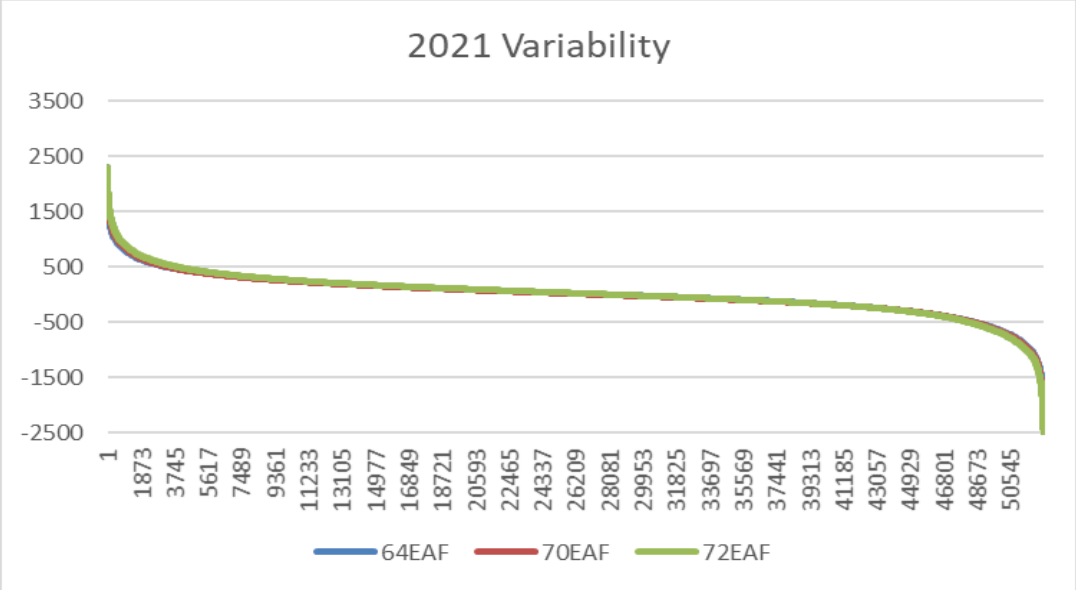

Figure 1: 2021 variability study results

Using Figure 1 above, the moderate Eskom generation performance scenario indicates that 575 MW of regulating up/down reserve is required in 2021.

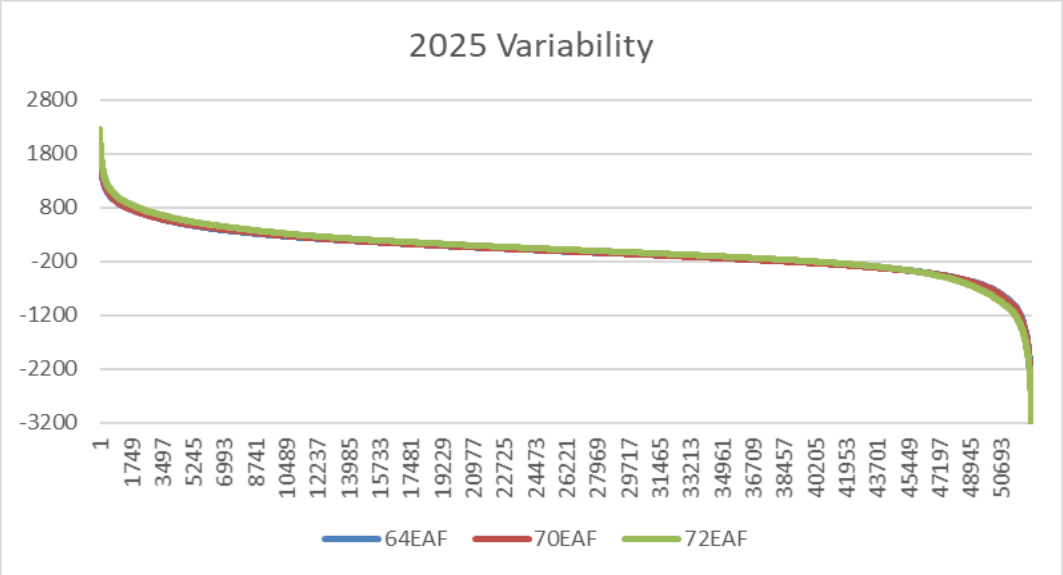

Figure 2: 2025 variability study results

Using Figure 2 above, the moderate Eskom generation performance scenario indicates that 666 MW of regulating up/down reserve is required in 2025.

The minimum Regulating Reserve requirements, taking load variation and renewable energy unpredictability into consideration, are given in Table 2 below:

Table 2: Regulating up and down reserve requirements

Reserve	Period	2021/22 MW	2022/23 MW	2023/24 MW	2024/25 MW	2025/26 MW
Regulating up	Summer (Pk/off pk)	575	595	615	635	660
	Winter (Pk/off pk)	575	595	615	635	660
Regulating down	Summer (Pk/off pk)	575	595	615	635	660
	Winter (Pk/off pk)	575	595	615	635	660

Regulating reserve capacity (regulating up + regulating down) is determined by AGC high and low limits set at the generator such that the generator will regulate up and down.

3.4 TEN-MINUTE RESERVE

3.4.1 Description

Ten minute reserve is generating capacity or demand side managed load that can respond within 10 minutes when called upon. It may consist of offline quick 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 reserve to the required levels after an incident. Ancillary Services requires Ten minute reserve resources which may be used for up to 600 hours per year (assuming a usage over 50 weeks, 4 days and 3 hours per day). In addition, if the cost of any potential Ten minute reserve resource is close to or higher than gas turbines, it must be used as an emergency reserve resource. Any new Ten

minute reserve resource must have no onerous energy restrictions since this reserve may be required to be used every day.

3.4.2 Technical Requirements

A) Credible multiple contingency requirement

A credible multiple unit contingency trip is defined in the SA grid code as a typical loss of three coal fired units. To ensure reliability it was assumed that the total operating reserve should be sufficient to replace the loss of the three biggest coal fired units. Thus, from 2021/22 to 2025/26, the biggest three units have a capacity of 3 x 722 = 2166 MW. The Ten minute reserve requirement = Total Operating – Instantaneous – Regulating

B) SAPP Requirement

SAPP Operating Guidelines state that a minimum of 1011 MW of operating reserve is currently required from the Eskom control area.

The credible multiple contingency criterion yields a higher requirement for Ten minute reserves. The Ten minute reserve requirements are shown in Table 3 below:

Table 3: Ten-minute reserve requirements

Period	2021/22 MW	2022/23 MW	2023/24 MW	2024/25 MW	2025/26 MW
Summer Peak/ Off-Peak	775	755	735	715	690
Winter Peak/ Off-Peak	975	955	935	915	890

3.5 EMERGENCY RESERVE

3.5.1 Description

Emergency reserves should be fully activated within 10 minutes. Emergency reserves are utilised in accordance with the guideline [5]. Emergency reserves include interruptible loads, generator emergency capacity (EL1), and gas turbine capacity. Emergency reserve capacity is required less often than Ten minute reserve. The reserve must also be under the direct control of National Control. These requirements arise from the need to take quick action when any abnormality arises on the system.

3.5.2 Technical requirements

The technical requirement is based on the total average of unplanned capacity losses from the entire generation fleet. The optimum emergency reserve requirement is based on catering for forced outages or generator trips for 95% of the time.

A) Contingency study

The purpose of this study was to determine the minimum emergency reserve capacity to ensure that the power system is returned to normal conditions following disturbances. A production simulation study was undertaken to determine the optimum reserve capacity. Various demand and generation performance scenarios were considered i.e. Low demand low performance, moderate demand moderate performance, high demand high performance. Figure 3 below depicts simulation results for 2021 and Figure 4 depicts simulation results for 2025.

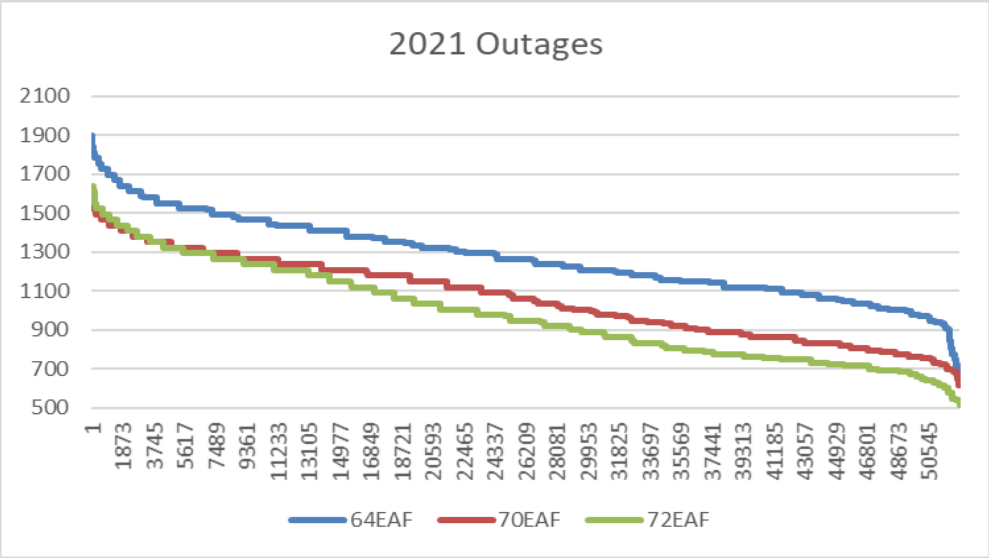

Figure 3: 2021 contingency study results

Using Figure 3 above, the moderate Eskom generation performance scenario indicates that 1380 MW of emergency reserve is required in 2021.

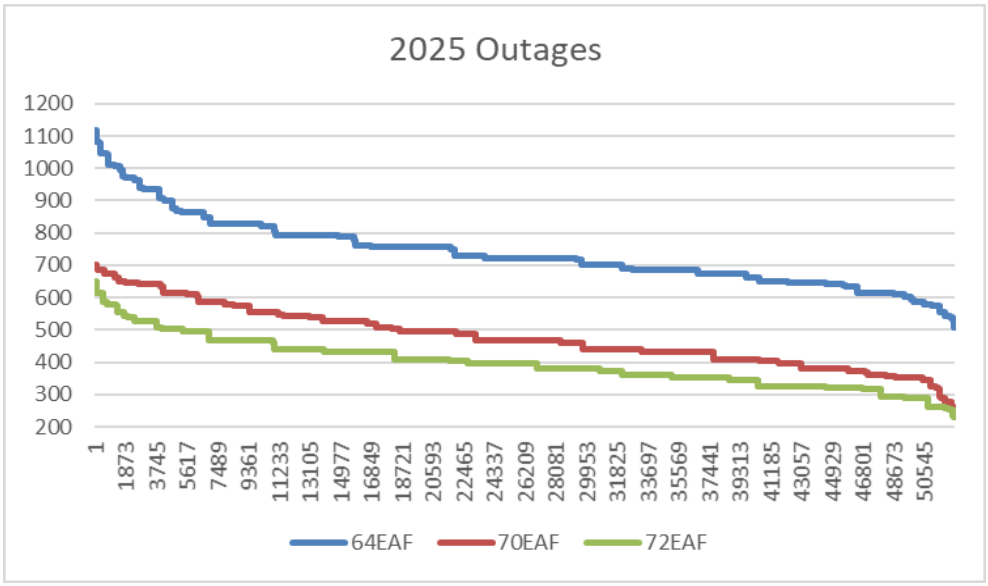

Figure 4: 2021 contingency study results

Using Figure 4 above, the moderate Eskom generation performance scenario indicates that 648 MW of emergency reserve is required in 2025.

Table 4: Emergency reserve requirements

Period	2021/22 MW	2022/23 MW	2023/24 MW	2024/25 MW	2025/26 MW
Winter Peak/ Off peak	1300	1140	1000	800	650
Summer Peak/ Off peak	1300	1140	1000	800	650

3.6 SUPPLEMENTAL RESERVE

3.6.1 Description

Supplemental reserve is generating or demand side load that can respond in 6 hours or less to restore operating reserves. This reserve must be available for at least 2 hours [2]. This capacity is used to ensure an acceptable day-ahead risk.

3.6.2 Technical requirements

The technical requirement is based on the average loss of coal fired power station capacity greater than 3000MW, which was calculated to be approximately 3800 MW. This capacity should be replaced by the sum of operating, emergency and supplemental reserve capacity. Thus, Supplemental capacity = Total PS capacity – Operating reserve - Emergency reserve. The supplemental reserve requirements are as follows:

Table 5: Supplemental reserve requirements

Period	2021/22 MW	2022/23 MW	2023/24 MW	2024/25 MW	2025/26 MW
Winter Peak/ Off peak	300	460	600	800	950
Summer Peak/ Off peak	300	460	600	800	950

RESERVE REQUIREMENTS SUMMARY

The overall reserve requirements may be summarised as follows:

Table 6: Summary of reserve requirements

Reserve	Season	Period	2021/22 MW	2022/23 MW	2023/24 MW	2024/25 MW	2025/26 MW
Instantaneous	Summer	Peak	650	650	650	650	650
		Off peak	850	850	850	850	850
	Winter	Peak	650	650	650	650	650
		Off peak	850	850	850	850	850
Regulating	Summer	Peak	575	595	615	635	660
		Off peak	575	595	615	635	660
	Winter	Peak	575	595	615	635	660
		Off peak	575	595	615	635	660
Ten-minute	Summer	Peak	975	955	935	915	890
		Off peak	775	755	735	715	690
	Winter	Peak	975	955	935	915	890
		Off peak	775	755	735	715	690
Operating	**Summer/ Winter**	**Peak/ Off peak**	**2200**	**2200**	**2200**	**2200**	**2200**
Emergency			**1300**	**1140**	**1000**	**800**	**650**
Supplemental			**300**	**460**	**600**	**800**	**950**
Total			**3800**	**3800**	**3800**	**3800**	**3800**

4. SYSTEM RESTORATION FACILITIES

The Grid Code requires that the System Operator contract with two strategically placed facilities for black start services and adequate unit islanding services to restore the system following a total blackout or an incident in which power to part of the system is interrupted. Black start facilities need to be capable of starting themselves, energising a portion of the transmission network and starting up other connected base load generators as part of the restoration of the IPS. A unit islanding generator is capable of maintaining its own stability and supplying its own auxiliaries while being disconnected from the IPS.

4.1 BLACK START TECHNICAL REQUIREMENTS

Black start facilities need to meet those requirements specified for them in the Grid Code as well as those requirements specified by the System Operator.

A) Grid Code Requirements

The Grid Code requires that:

1. At least two suitable black start facilities are contracted.
2. The System Operator is required to determine the minimum specifications for the black start facilities.
3. The Power Station must prove the capability of the facility by doing partial and full black start tests periodically, every 3 and 6 years as required by the Grid Code. This shall be done in accordance with the latest version of the operating standard EST 32-1190. The partial and full tests are similar, both requiring that the isolated facility start up the involved generators and energise a defined part of the transmission network. The full test, however, goes on to pick up load to fully prove the capability of the black start facility.

4. The designated unit can resynchronise to / energise the power system within four hours of shutdown.

B) System Operator Technical Requirements

The System Operator requires that further technical requirements be met:

1. Each black start facility shall be available at least 90% of the year as long as maintenance and repairs are coordinated so that there is at least one facility available at all times.
2. Geographical location of a unit capable of black starting has to allow for restoration without technical constraints.
3. The station shall conduct periodic self-start diesel generator compliance monitoring tests as required by the System Operator. These tests include testing the self-start facility and monitoring fuel and water levels. They also include running a full speed no load once a week for 2 hours and full speed base load test once a month for 3 hours.
4. There shall be sufficient water/fuel for three black start attempts on the unit at all times.
5. Units contracted for black start shall be capable of providing sufficient reactive power to control the declared transmission voltages between ±5% of nominal voltage.
6. The unit shall be capable of picking up load blocks of 30 to 50 MW.
7. The black start facility shall be capable of maintaining the frequency within 49 Hz to 51 Hz during energisation and load pick up.
8. Due to the fact that system failures can occur during restoration, the power station shall be capable of sequentially black starting a unit up to 3 times.

C) Additional Requirements for Pump Storage or Hydro Black Start Facility

A pumped storage / hydro station shall be capable of self-starting one or more units, energising a part of the grid (line to a thermal station as identified by the SO) and so providing auxiliary power to enable a thermal unit to start within four hours of shutdown of the thermal unit.
The pumped storage / hydro facilities certified as black-start facilities are required to have at least two units that are capable of operating in SCO all the time.

4.2 UNIT ISLANDING TECHNICAL REQUIREMENTS

Unit islanding is a mandatory ancillary service for generating units certified for islanding. To prove the capability of the station to be certified, the South African Grid Code (Network Code, Appendix A2.3.2 (SAGC) requires a once off prototype test on one unit to be performed. Once the units are certified and contracted, the units are expected to prove their capability every six years, or after a major overhaul, whichever comes first.

A) Grid Code Requirements

The requirements specified in the Grid Code include the following:

1. Units that do not have a black start facility or self-start capability shall island when required except if construction occurred before the implementation of the Grid Code and without an HP bypass facility designed for islanding. Thus all the units commissioned after the founding of the Grid Code should have Islanding capabilities.
2. Return-to-service units are currently exempted from this requirement as they do not have HP bypass facilities required for islanding.
3. The SAGC specifies that only units rating greater than 200 MVA must have the ability to island (Table 1a of the Network Code).
4. The units are expected to disconnect from the power system at full load and sustain the islanding for two hours.

5. The prototype test is only done on new units with routine testing required every six years.
6. The once off prototype test requires the unit be islanded from full output and remain in an islanded state for a minimum of two hours.
7. Routine tests shall be performed on each unit every six years or after each general overhaul whichever comes first. Routine tests require a unit to island from 60% of MCR and remain there for 20 minutes, under normal operating conditions.
8. The tests shall be carried out in accordance with the latest version of procedure EPC 32-951, “Certification/ Decertification Procedure for Turbo-Generator Unit Islanding” and “Steam Turbine Unit Islanding, Load Rejection and Speed Control Verification Standard” (240-56030600).

5. REACTIVE POWER AND VOLTAGE CONTROL

Reactive power supply and voltage control form part of the ancillary services required by the System Operator to efficiently perform its main function of supplying electrical power.

5.1 TECHNICAL REQUIREMENTS

The technical requirements for reactive power and voltage control include requirements from the Grid Code, Renewables Grid Code and System Operator.

A) Grid Code Requirements for Conventional Generation

1. As required by the Grid Code, Network Code, all units greater than 100 MW shall be capable of supplying rated power output (MW) at any point between the limits of 0.85 power factor lagging and 0.95 power factor leading at the HV side of the generator transformer.
2. Reactive power output shall be fully variable between these limits under AVR, manual or other controls.
3. SO shall control power station export/import of reactive power through TEMSE or telephone.
4. When a unit is in pumping or generating, reactive power supply is mandatory in full operating range
5. Voltages shall not deviate by more than ±5% from declared voltages under normal operating conditions.
6. Gas Turbine units build after the implementation of the Grid Code shall be capable of operating in SCO.
7. Generators shall conduct prototype and routine tests to demonstrate reactive capability.

All units built after the implementation of the South African Grid Code shall be equipped with power system stabilisers as defined in IEC 60034, IEEE42. Reactive output shall be fully variable so as to achieve acceptable levels of voltage (± 5%) under automatic or manual control.

B) Grid Code Requirements for Renewables Power Plants (RPP)

1. During start-up / energising, the Renewables Power Plants (RPP) may only consume or export not more that 5% of rated reactive power from the transmission system.

2. Different power factor categories (A – C) depending on the output power are specified in the RPP Code.
3. The RPP shall be equipped with reactive power control functions capable of controlling the reactive power supplied by the IPP at the point of connection (POC) as well as a voltage control function capable of controlling the voltage at the POC via orders using set points.

4. The RPP shall ensure that they can function/operate under any of the three different modes mentioned below. Furthermore the reactive power and voltage control functions are mutually exclusive, which means that only one of the three functions mentioned below can be activated at a time:
    a. Q-control
    b. Power Factor–control
    c. Voltage-control

5. The applied parameter settings for reactive power and voltage control functions shall be determined before commissioning by the Network Service Provider (NSP) in collaboration with the SO.

C) System Operator (SO) Requirements

1. SO shall use peaking stations (pump storage and OCGTs) in SCO for voltage control.
2. All installed thermal and peaking stations will be used for voltage control at the discretion of the SO.
3. All generators shall have automatic voltage regulators (AVR)/converters in an automatic voltage control mode.
4. All generators shall inform/update SO of any restriction that might affect the reactive power support.

5. All generators capable of voltage control shall be required to do reactive capability tests as stipulated in Eskom Work Instruction 240-88425452, “Generating unit reactive power and voltage control certification procedure”.

6. CONSTRAINED GENERATION

6.1 INTRODUCTION

The Grid Code [3] requires that the System Operator manage real-time system constraints within safe operating limits, using constrained generation as one of the ancillary services as required. In particular, it requires multiple outages of a credible nature to be studied to ensure that the operation of the system protects against cascading outages for such an event, wherever practical. To support the MYPD, this requires the System Operator to identify national system constraints over a 5 year horizon, define relevant system problems by establishing those constraints affecting the capacity to meet demand, and draw conclusions on the need for this service. An input in establishing the need for this service includes determining the constraints with duration beyond a few hours that have a significant impact and high probability. This requirement excludes the long duration planned transmission maintenance outages that are coincident with full generation at Matimba from the list of national constraints requiring constrained generation where they can be avoided, for example, as such planned outages can be coordinated with Matimba generation outages where possible.

6.2 NATIONAL SYSTEM CONSTRAINTS

The SA Grid Code System Ops Code, section 4.3 specifies that any power stations run out of schedule to respect operational limits be compensated for the resulting financial loss so suffered as a consequence of the lack of IPS capacity and related market rules, as part of constrained generation. The power station must be financially compensated for the opportunity cost, loss of profit or additional cost not recovered from the tariff for this operation.

6.2.1 Cape Constraint

Consistent with the System Operator's obligations outlined in the Grid Code to operate the IPS and security monitoring on a system-wide basis to ensure safe, reliable and economic operation of the IPS, the risk of refuelling Koeberg Nuclear Power Station (KNPS) during winter has again been assessed. Given the increasing renewable generation in the region, a production simulation study using a modified production plan for KNPS refuelling during winter was used to establish the associated cost for peaking generation of such a proposition. From this, the following OCGT constrained generation requirements were determined:

Table 7: Summary of OCGT energy requirements for winter refuelling of KNPS

Financial year	Study category	Max units required	OCGT energy needed (GWh)
2021/22	Planned operation (N-0)	0	0
	Non-refuel (N-1)	0	0
	Refuel (N-1-1)	0	0
2022/23	Planned operation (N-0)	0	0
	Non-refuel (N-1)	0	0
	Refuel (N-1-1)	0	0
2023/24	Planned operation (N-0)	0	0
	Non-refuel (N-1)	0	0
	Refuel (N-1-1)	0	0
2024/25	Planned operation (N-0)	0	0
	Non-refuel (N-1)	0	0

	Refuel (N-1-1)	0	0
2025/26	Planned operation (N-0)	0	0
	Non-refuel (N-1)	0	0
	Refuel (N-1-1)	0	0

Based on these results, the System Operator chooses to continue to not impose any restriction on when KNPS may be refuelled.

Regarding the operation of Palmiet Pumped Storage Scheme, the System Operator maintains the minimum top dam level at 5 unit generating hours (UGH). The restriction on Palmiet not to be on planned maintenance during refuelling outages at KNPS remains.

6.2.2 Northern Grid Constraint

Construction challenges on the special protection scheme in the Northern Grid require spinning to be taken at Matimba. This action will require other more expensive generating stations to replace this capacity, increasing the cost of meeting demand. Considering both production simulation results and experience, the System Operator has chosen to allocate 52 GWh to Matimba and Medupi for constrained generation for this region over the 2021/22 financial year.

7. ACCEPTANCE

This document has been seen and accepted by:

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8. REVISIONS

Date	Rev.	Compiler	Remarks
November 2020	1.0	VG Smith	New document

9. DEVELOPMENT TEAM

The following people were involved in the development of this document:

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10. SUPPORTING CLAUSES

10.1 Scope

This document specifies the technical requirements for ancillary services for financial years 2021/22 to 2025/26.

The purpose of the document is to make the System Operator's requirements known to ensure a reliable network and provide optimal usage of ancillary services for the next five financial years.

All suppliers of ancillary services need to meet all aspects of the South African Grid Code relating to these services.

10.2 Abbreviations and Definitions

CPS: Control Performance Standard
GX: Generation division
IPS: Interconnected Power System

KNPS: Koeberg Nuclear Power Station
OCGT: Open cycle gas turbine
OP: Operating Procedure
OS: Operating Standard

Peak and Off-peak: Peak periods are considered only during weekdays. There are two peak periods in the daily system load profile, morning peak and evening peak, occurring at different times of the day during winter and summer months. Public holidays are treated the same as weekends with no peak periods. In winter, identified as May to August, the morning peak occurs from 06:00 to 09:00 and the evening peak occurs from 17:00 to 20:00. In summer, covering the remainder of the year outside winter, the morning peak occurs from 09:00 to 12:00 and the evening peak from 18:00 to 21:00. Thus the peak periods occur for six hours of the day every weekday.
Residual load: That portion of the load not met by renewable generation

RE: Renewable energy (generation)
SAPP: Southern African Power Pool
SO: System Operator
SOG: System Operator Guideline
UGH: Unit generating hours

10.3 Roles and Responsibilities

The provision of these requirements is monitored regularly via the monthly performance reports.

10.4 REFERENCES

1. Ancillary Services Technical Requirements Methodologies 240-159161192
2. Glossary for reserves related terms 240-65859861
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5. Control of system frequency under normal and abnormal conditions 240-154245832
6. “Instantaneous Reserves Requirements Study 2018”, Document Number 342-547
7. Ancillary Services Technical Requirements Constrained Generation Study report 2015/16 – 2019/20, VG Smith, 342-299
8. WORK PACKAGE 2 – RE predictability and the need for reserves (WASA, CorWind)