SYSTEM OPERATOR

Ancillary Services Technical Requirements for 2018/19 – 2022/23

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ANCILLARY SERVICES TECHNICAL REQUIREMENTS FOR 2018/19 – 2022/23

1. INTRODUCTION

This document specifies the technical requirements for ancillary services for the period 2018/19 till 2022/23. Its purpose is to make the technical requirements of the System Operator for ancillary services known. 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, 2018/19.

The following requirements are defined as ancillary services:

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

2. METHODOLOGY

The methodologies on which the 2018/19 – 2022/23 ancillary services technical requirements are based is 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 procedure 342-141, “Control of System Frequency under Normal and Abnormal Conditions”.

3.2 INSTANTANEOUS RESERVE

3.2.1 Description

Instantaneous reserve is generating capacity or demand side managed load fully available within 10 seconds to arrest a frequency excursion outside the frequency deadband. The 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 Network 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. Renewable

generation was factored in the study. The minimum requirements, which are based on only generators providing instantaneous reserves, are shown in

Table 1.

Table 1: Instantaneous reserve requirements

Season	Period	2018/19 MW	2019/20 MW	2020/21 MW	2021/22 MW	2022/23 MW
Summer/ Winter	Peak	500	500	500	500	500
	Off peak	800	800	800	800	800

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 the following requirements:

i) The load pick-up and drop off capacity that exceeds the average ten-minute demand (based on 4-second SCADA) for a given % period. A load variation study was done to determine the minimum regulating requirements.

ii) Compliance with SAPP CPS performance criterion requirement (ensures frequency is within dead band for 95% of the time).

A) Load variation study

The purpose of this study was to determine the average load pick up and drop off capacity from one ten minute period to the next over 24 hours. The study was done based on typical weekly load profiles in summer and winter. It was noted that there is at least one hour in the morning and in the evening during which load changes rapidly. This is when demand changes from night to day (in the morning) and from day to night (in the evening). These hours were therefore excluded to avoid skewing the results. Two hours were excluded in summer and three hours were excluded in winter. This study only considers genuine load variations within the hour that are expected to be met with regulating reserve.

The results are depicted below:

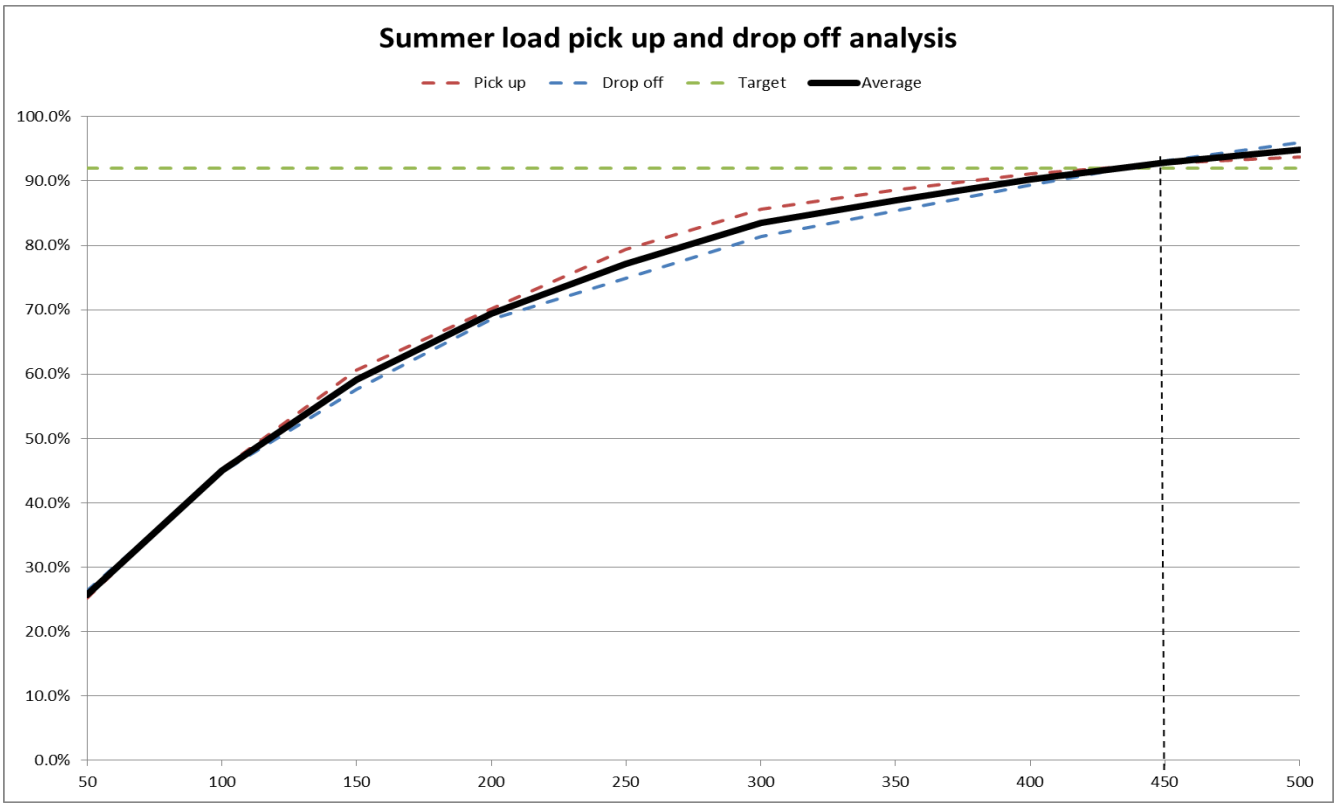

Figure 1: Summer average ten minute load pick up and drop offs

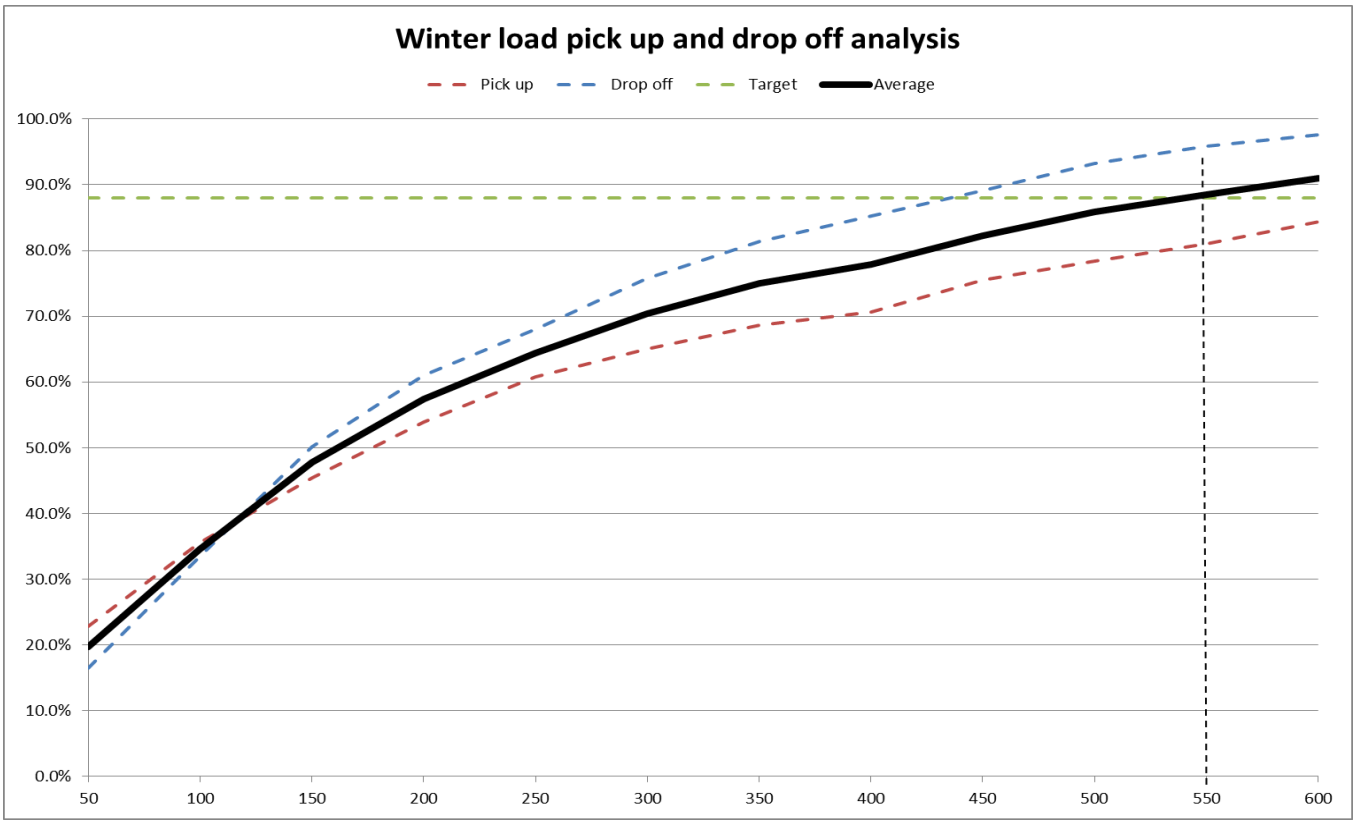

Figure 2: Winter average ten minute load pick up and drop offs

In summary, the results are:

Season	Reg up requirement	Reg down requirement	Regulating up/ down requirement
Winter (May – Aug) MW	700	450	**550**
Summer (Rest of year) MW	450	450	**450**

B) Renewable energy predictability and the need for reserves study

A study led by SANEDI (2016) indicated that secondary reserve requirements are expected to increase by 3 – 7% between 2020 and 2025 [8]

The minimum Regulating Reserve requirements are given in table 2 below:

Table 2: Regulating up and down reserve requirements

Reserve	Period	2018/19 MW	2019/20 MW	2020/21 MW	2021/22 MW	2022/23 MW
Regulating up	Summer (Pk/off pk)	450	450	450	470	500
	Winter (Pk/off pk)	550	550	550	570	600
Regulating down	Summer (Pk/off pk)	450	450	450	470	500
	Winter (Pk/off pk)	550	550	550	570	600

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 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 in 2018/19 financial year, 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 1021 MW of operating reserve is currently required from the Eskom control area. The Ten minute reserve requirement = Total operating – Instantaneous – Regulating.

The Ten-minute Reserve requirements are shown in Table 3 below.

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	2018/19 MW	2019/20 MW	2020/21 MW	2021/22 MW	2022/23 MW
Summer Peak	1250	1250	1250	1230	1200
Summer Off- Peak	950	950	950	930	900

Winter Peak	1150	1150	1150	1130	1100
Winter Off-Peak	850	850	850	830	800

3.5 SUPPLEMENTAL RESERVE

3.5.1 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].

3.5.2 Technical requirements

There are costs associated with providing supplemental DR reserve, thus the total amount procured should be optimised based on reliability and cost. Supplemental DR capacity was determined to minimise the use of more expensive emergency resources. This is mainly based on the relative energy costs of demand response compared to energy costs of gas turbines, as well as the capacity charge paid to customers for making their capacity available to be reduced when the need arises. If gas is cheaper than DR at any time, then no DR should be utilised before using gas turbines (including OCGT). System Operator needs intra-day supplemental reserve capacity which is flexible i.e. supplemental reserve capacity contracted (annually) and readily available to be dispatched on the day. This is to mainly cater for intraday risks that are likely to occur e.g. load losses, forecast errors (including renewables), delays on returning plant to service etc. Supplemental reserve capacity is used to optimise dispatch cost. The supplemental reserve requirements are as follows:

Table 4: Supplemental reserve requirements

Period	2018/19	2019/20	2020/21	2021/22	2022/23

	MW	MW	MW	MW	MW
Peak/ Off peak	300	300	300	300	300

3.6 EMERGENCY RESERVE

3.6.1 Description

Emergency reserves should be fully activated within 10 minutes. Emergency reserves are utilised in accordance with procedure 342-141[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.

3.6.2 Technical requirements

The technical requirement is based on the worst contingency being a loss of the largest power station, which should be replaced by the sum of operating, supplemental and emergency reserve capacity. Having determined operating and supplemental reserves, the emergency reserve requirements are as follows:

Table 5: Emergency reserve requirements

Period	2018/19 MW	2019/20 MW	2020/21 MW	2021/22 MW	2022/23 MW
Peak/ Off peak	1300	1900	1900	1900	1900

3.7 RESERVE REQUIREMENTS SUMMARY

The overall reserve requirements may be summarised as follows:

Table 6: Summary of reserve requirements

Reserve	Season	Period	2018/19 MW	2019/20 MW	2020/21 MW	2021/22 MW	2022/23 MW
Instantaneous	Summer	Peak	500	500	500	500	500
		Off peak	800	800	800	800	800
	Winter	Peak	500	500	500	500	500
		Off peak	800	800	800	800	800
Regulating	Summer	Peak	450	450	450	470	500
		Off peak	450	450	450	470	500
	Winter	Peak	550	550	550	570	600
		Off peak	550	550	550	570	600
Ten-minute	Summer	Peak	1250	1250	1250	1230	1200
		Off peak	950	950	950	930	900
	Winter	Peak	1150	1150	1150	1130	1100
		Off peak	850	850	850	830	800
Operating	**Summer/ Winter**	**Peak/ Off peak**	2200	2200	2200	2200	2200
Supplemental			300	300	300	300	300
Emergency			1300	1900	1900	1900	1900
Total			**3800**	**4400**	**4400**	**4400**	**4400**

4. SYSTEM RESTORATION FACILITIES

The Grid Code requires that the System Operator contract with two strategically placed facilities for black start services and 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 first unit can energise a portion of 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) and so providing auxiliary power to enable a thermal unit to start within four hours of shutdown of the thermal unit.

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 A2.3.8) (SAGC) requires a once off test to be performed. Once certified and contracted, a unit is expected to prove its 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 an HP bypass facility required for islanding.
3. The SAGC specifies that only units rating greater than 200 MVA will be certified.
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 “Standard for Steam Turbine Unit Islanding, Load Rejection and Speed Control Verification” (GGS 0500).

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 Turbines units build after the implementation of a 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 particularly, 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 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 outage can be coordinated with Matimba generation outages.

6.2 NATIONAL SYSTEM CONSTRAINTS

The Grid Code requires that those power stations which run out of schedule as part of constrained generation must be financially compensated for the opportunity cost, loss of profit or additional cost not recovered from the tariff of this operation.

6.2.1 Cape Constraint

Since the previous analysis of the need for constrained generation in the Cape, the 765 kV strengthening to the region has been completed between Kappa and Sterrekus. Given that the hourly demand in the Western Grid that Eskom dispatchable generation and regional

transmission corridors must support is not expected to exceed 3450 MW in 2018 and continue to trend downwards as more renewable generation is added in the region, there is no constrained generation support required from regional peaking generation.

Based on the assumed regional demand, generation plant performance and cost, 0 GWh is required from the OCGT for constrained generation to cater for the N-1-1 refuel contingency for period under review.

To limit the need for use of expensive local generation, Koeberg will continue to be restricted to refuel outside of winter (01 May to 31 August). This restriction on Koeberg requires that it replace some of its partially spent fuel with new fuel, incurring a financial loss due to the Cape network constraint. Koeberg must be compensated financially for this.

6.2.2 Northern Grid Constraint

Construction challenges in the Northern Grid require spinning to be taken at Matimba and Medupi. This action will require other more expense generating stations to replace this capacity, increasing the cost of meeting demand. Based on the merit order of the displaceable generation, the results of the production simulation show that Matimba and Medupi will collectively be constrained down by 2,120 GWh over the 2018/19 financial year.

7. SUPPORTING CLAUSES

7.1 Scope

This document specifies the technical requirements for ancillary services for financial years 2018/19 to 2022/23.

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.

7.2 Abbreviations and Definitions

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

SAPP: Southern African Power Pool
SO: System Operator
SOG: System Operator Guideline

7.3 Roles and Responsibilities

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

7.4 REFERENCES

1. Ancillary Services Technical Requirements Methodologies 342-291
2. Glossary for reserves related terms 240-65859861
3. “The South African Grid Code: System Operator Code”, Rev 9.0 July 2014.
4. Integrated Resource Plan for Electricity 2010 – 2030, Government Gazette, no. 34263, 06 May 2011
5. Control of system frequency under normal and abnormal conditions 342-141
6. “Instantaneous Reserves Requirements for 2014 - 2016”, Document Number 342-289
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)