Eskom	STANDARD	Transmission System Operator

Title: **Certification and Performance Monitoring for Battery Energy Storage Facility Reserves**

Unique Identifier: **240-16706821**

Alternative Reference Number: **N/A**

Area of Applicability: **Eskom Holdings SOC Ltd**

Functional Area: **Ancillary Services**

Revision:

Total Pages: **31**

Next Review Date: **May 2026**

Disclosure Classification: **PUBLIC**

Compiled by	Supported by	Supported by	Authorized by
Matome Malematja	**ST Joseph**	**L Padachi**	**I Fick**
Ancillary Services Engineer	**Ancillary Services Manager**	**Corporate Specialist Demand Response**	**General Manager System Operator**
Date: 26/05/2023	Date: 26/05/2023	Date: 05/06/2023	Date: 5 June 2023

Content

Page

Figures

Tables

1. INTRODUCTION

Ancillary Services are procured based on technical requirements to ensure a safe and reliable operation of the power system. Battery Energy Storage Facilities are required to adhere to all requirements as defined in the Grid Code and Southern African Power Pool operating guidelines.

2. SUPPORTING CLAUSES

2.1 Scope

2.1.1 Purpose

The purpose of this document is to outline the procedure for certification and performance monitoring of Battery Energy Storage Facilities that will be contracted to provide Ancillary Services to the System Operator.

2.1.2 Applicability

This document shall apply to all Battery Energy Storage Facilities that intend to enter into an agreement with SO for Ancillary Services provision.

2.1.3 Effective date

This document is effective from the date of authorisation.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

[1] South African Grid Code (SAGC)
[2] SAPP Operating Guidelines.
[3] Latest Ancillary Service Technical Requirements

2.3 Definitions

Definition	Explanation
Acceptable performance	Means a percentage performance greater than or equal to 90% over a month or reporting period.
Decertification	Is the process of excluding a resource which is not performing adequately, or is no longer offered, for ancillary services provision.

Facility	Means a generation facility which converts primary energy to electrical energy which consists of one or more Power Generating Modules connected to a network at one or more Connection Points.
Frequency Incident	Is an event where the system frequency drops to below the target frequency for more than the specified delay time.
Reserve Resource	A facility that has been certified to provide one or more reserves ancillary services.
Recertification	This is the process of re-determining the resource's capability.

2.4 Abbreviations

Abbreviation	Explanation
AGC	Automatic Generation Control
AMS	Average of Maximum and Sustained
ARR	Actual Ramp Rate
AS	Ancillary Services
BESF	Battery Energy Storage Facility
CE	Control Error
DRR	Declared Ramp Rate
EMS	Energy Management System
FSM	Frequency sensitive mode
IR	Instantaneous Reserve
IPS	Interconnected Power System
NC	National Control
NCSS	National Control Systems Support
NO	National Operations
ODP	Overall Duration Performance
ORP	Overall Ramp Performance
PBC	Point of Battery Energy Storage Facility Connection
POC	Point of connection
RDE	Ramping Duration Error
ROCOF	Rate of Change of Frequency
SAGC	South African Grid Code
SCADA	System Control and Data Acquisition System
SO	System Operator

TEMSE	Transmission Energy Management System Enhancement project
TF	Target Frequency
TMR	Ten Minute Reserve

2.5 Roles and Responsibilities

2.5.1 Ancillary Services

The Ancillary Services section is responsible for determining minimum reserve requirements for each reserve category, budgeting and contracting for the services. In addition, AS certifies and manages the performance of reserve resources and sets the standards for performance.

2.5.2 National Control

National Control (NC) operates the Power System in a safe, economical and secure manner, and maintains reliability and quality of supply. NC maintains the frequency within the statutory limits by balancing supply and demand.

2.5.3 National Operations

National Operations is responsible for scheduling of reserve resources as per grid code's scheduling and dispatch rules.

2.5.4 National Control Systems Support

National Control Systems Support provides software support to Ancillary Services by maintaining TEMSE database and other performance monitoring programs.

2.5.5 Battery Energy Storage Facilities

Battery Energy Storage Facility contracts with SO via ancillary services agreements to provide reserves to SO. BESF offer certified and contracted reserves daily and adhere to minimum performance requirements. Where SO highlights non-conformance, the BESF shall ensure that steps are taken to rectify performance as soon as possible.

3. CERTIFICATION AND DE-CERTIFICATION OF BESF

3.1 Pre-certification Process

The BESF will ensure that all systems, interfaces and signals are commissioned before applying for certification. The BESF will apply formally in writing, to the AS section for certification and send the information required about each resource as listed in section 5. Appropriate metering of the facility must be available to NC at the required resolution as explained in section 4.

The test date will be agreed upon between the BESF and SO. For new resources, the test date will be at least 10 working days after the request was received to enable the facility to be registered on the relevant SO system and for the AS staff to arrange the necessary tests.

3.2 Certification Process

The details of the required tests are given under each category. Once the test is completed successfully, AS will compile the test report and archive it. A signed certificate will be prepared by AS and sent to the BESF owner within 10 working days after performing the test. information about the facility will also be stored as listed in Section 5. Any costs incurred by the BESF in the certification process will be for the account of the BESF.

3.3 Negotiated and compulsory derating

If the BESF performance remains below the acceptable performance for at least **three** consecutive months then AS may request the facility to accept a lower certified capacity provided it is above the minimum requirement as set out in section 3.5. The BESF or AS may at any time request a change up or down in the certified capacity of the facility. This may then be negotiated and agreed between the parties concerned.

3.4 De-certification Process

If the BESF performance is below the acceptable performance for at least **one** month, AS will request the BESF to investigate the root cause. If the problem is found to lie with SO, then SO shall fix the problem within a month. If the problem lies with the BESF, then the BESF shall fix the problem within one month.

If the BESF fails to rectify the performance of the facility within **three** months and the facility is below the minimum requirement such that it cannot be de-rated, then the facility shall be de-certified and its AS certificate withdrawn. After de-certification, no payments will be made until the facility is re-certified and the facility will be liable for a penalty as per agreement with SO.

3.5 Capacity Requirements for Certification

Table 1 below shows the minimum plant capacity required for ancillary services provision from BESF.

Reserve type	Min BESF size for certification (Single/Aggregated)[1]	Max Certified Reserve Capacity (% of Max Capacity) [2]	Max Response Time (Full activation)	Min required duration to maintain response	Notification time
Instantaneous	50 MW	100%	400 milliseconds	10 minutes	Automatic
Regulating	50 MW	100%	1 minute	1 hour	Automatic
Ten-minute	50 MW	100%	1 minute	2 hours	1 minute
Supplemental	50 MW	100%	1 minute	2 hours	10 minutes

Table 1: Capacity Requirements for Certification

[1] Single BESF plants shall be certified for reserves if their size is 50MW or higher (or as agreed with SO). Single BESF plants of at least B2 size (as stipulated in Grid Code) but less than 50MW must be aggregated to a minimum of 50 MW to be considered for certification as a single unit. [2]The BESF shall be certified for its maximum capacity, unless specified and agreed by the SO.

3.6 Measurements Data

Measurements data for each BESF should be available in real time via the relevant SO system. If metering data is not available or if it is not received by AS, the BESF must be informed immediately. Data may need to be retrieved from site. If the problem is on SO side, SO shall correct the problem within a month. If the problem lies on the BESF's side then the BESF has one month to fix the issue. During this period the resource is assumed to perform as per the certified capacity. If the issue is not resolved within a month, the facility's responses will be regarded as zero until the metering is again available.

In addition to telemetered data as per information code requirements, to enable certification and performance monitoring of BESF for **instantaneous reserve provision**, the following minimum measurements data is required:

Eskom device required	BESF device required	Data Sampling
Yes	Yes	20 ms

Table 2: IR measurements data requirements

Please see **Appendix B** for requirements on the IR measurement device.

4. RESERVES

The process for certification and performance monitoring of each ancillary services category is explained below. SO may add new ancillary services categories in the future.

4.1 Instantaneous Reserve

4.1.1 Requirement

BESF shall be able to achieve rapid injection/reduction of active power as required by the grid. IR must be fully activated within $\mathbf{t_1}$ and sustained for at least $\mathbf{t_2}$.

4.1.2 Certification

A. Test Period

The test period is one month or until at least two frequency events have occurred if this is longer than one month. Testing may occur during commissioning, provided that measurements data is received by the relevant SO system at a high resolution as agreed with SO. The BESF will not receive payments during the testing period. The status will remain “Uncertified” until the test is complete and the BESF is certified.

B. Response to Low Frequency Events

A low frequency event occurs whenever the frequency drops below the trigger frequency of $\mathbf{f_1}$ for longer than $\mathbf{t_0}$ as shown in Figure 1: Low frequency event (frequency plot)Figure 1 below. In the case where the trigger condition is Rate of Change of Frequency (ROCOF), the BESF will implement the settings as agreed with SO. A frequency incident is in force from when the trigger conditions mentioned above are met until the frequency recovers back into the dead band or for 10 minutes. For actual time settings please see **Appendix A.1.** For typical frequency settings please see **Appendix A.2.** Actual settings to be applied to specific BESF sites shall be provided by SO.

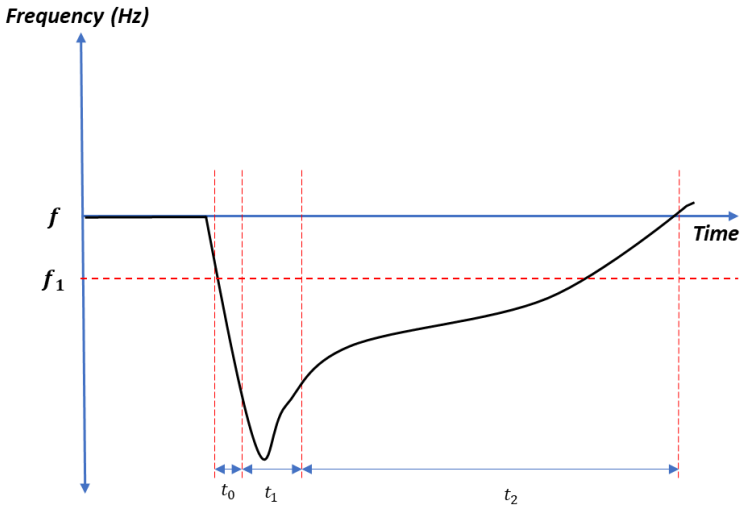

Figure 1: Low frequency event (frequency plot)

f_1 – Low frequency event BESF trigger frequency (Refer to **Appendix A.2**)

Discharge Mode

When a low frequency event occurs while in discharge mode, the BESF shall continue to discharge and deliver atleast the minimum IR capacity as stipulated in Table 1 within $\mathbf{t_1}$ and sustain the response for $\mathbf{t_2}$. Figure 2 below shows typical expected response. The certified capacity will be in-line with the limits as set out in Table 1.

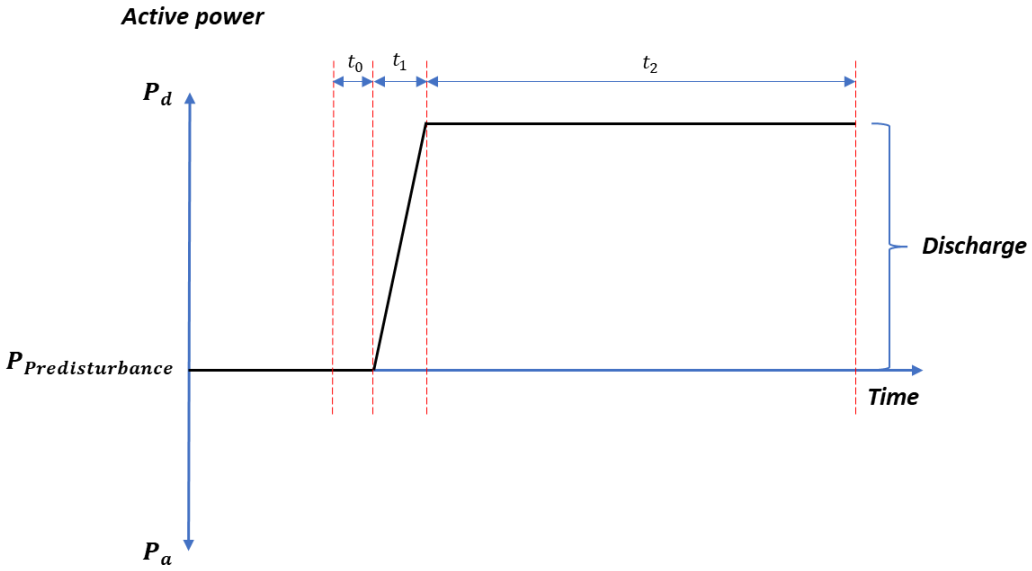

Figure 2: Low frequency event (BESF response)

P_d – Maximum active power delivered.

$P_{Predisturbance}$ – Active power before the start of an incident (Average over 3 cycles before the start of an incident)

P_a – Maximum active power absorbed.

Charging Mode

When a low frequency event occurs while in charging mode, the BESF shall immediately stop charging and change mode within $\mathbf{t_0}$ to discharge. The BESF shall then deliver at least the minimum capacity as stipulated in Table 1. A typical expected response is as shown in Figure 3 below.

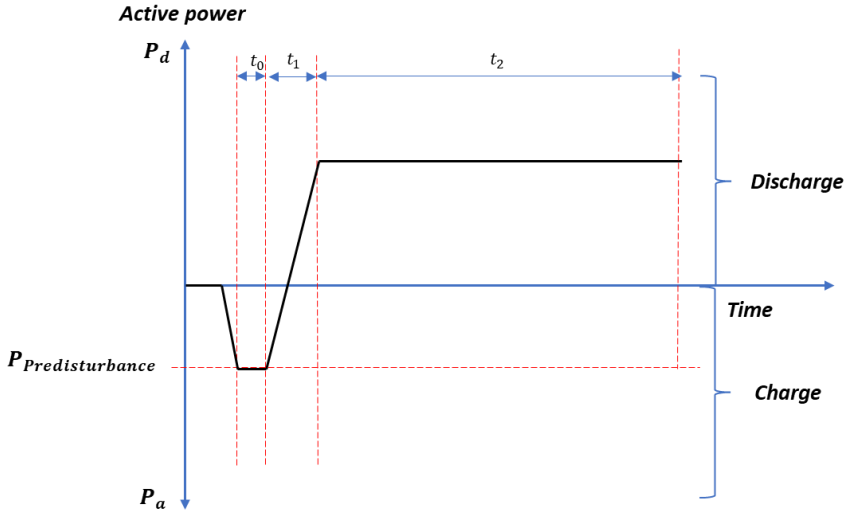

Figure 3: Low frequency incident (BESF mode change)

Fully Discharged

If the BESF has fully discharged or if it is operating close to maximum $\mathbf{P_d}$ such that it does not have capacity to deliver during a low frequency event, it shall not reduce output or change mode to charging while the system requires a positive response.

C. Response to High Frequency Events

A high frequency event occurs whenever the frequency increases above the target frequency of $\mathbf{f_2}$ for longer than $\mathbf{t_0}$ as shown in Figure 4 below. In the case where the trigger condition is Rate of Change of Frequency (ROCOF), the BESF will implement the settings as agreed with SO. A frequency incident is in force from when the trigger conditions mentioned above are met until the frequency recovers back into the dead band or for 10 minutes, whichever occurs first. For actual time settings please see **Appendix A.1**. For typical frequency settings please see **Appendix A.2**. Actual settings to be applied to specific BESF sites shall be provided by SO.

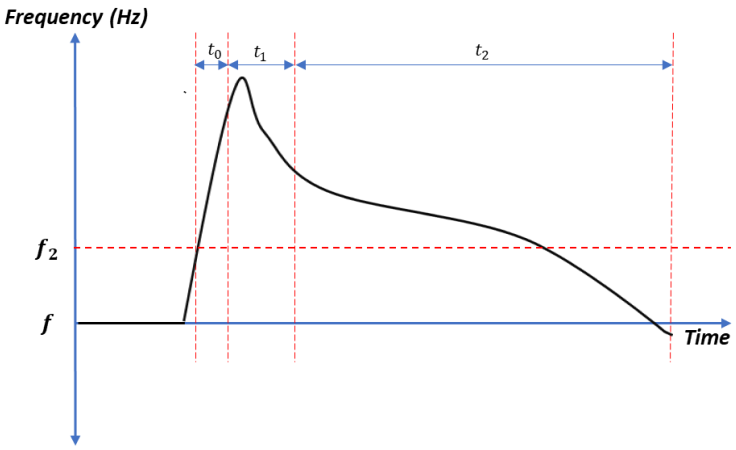

Figure 4: High frequency incident (frequency plot)

f_2 – High frequency incident BESF trigger frequency (Refer to **Appendix A**)

Discharge Mode

When a high frequency event occurs while in discharging mode, the BESF shall immediately stop discharging and change modes to charging within $\mathbf{t_0}$. The BESF shall then absorb at least the minimum capacity as stipulated in Table 1. Figure 5 below shows a typical expected response.

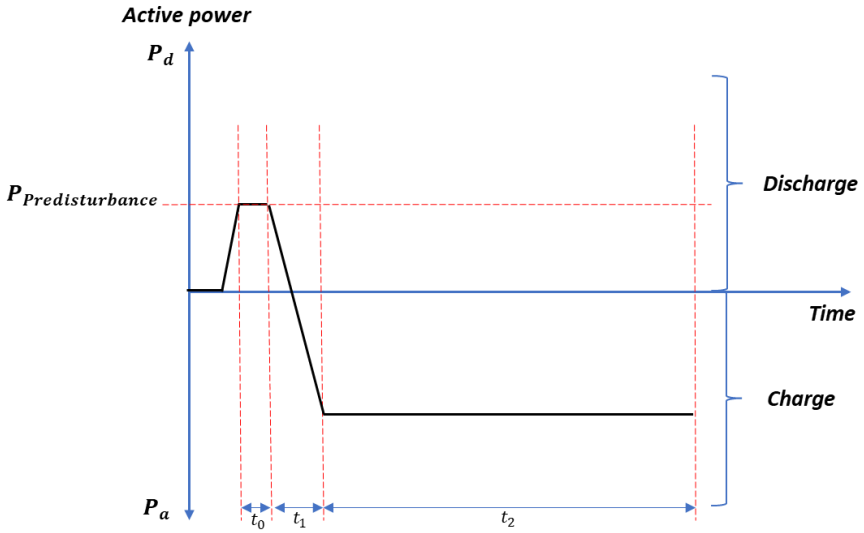

Figure 5: High frequency event (BESF mode change)

Charging Mode

When a high frequency event occurs while in charging mode, the BESF shall continue to charge and absorb at least the minimum IR capacity as stipulated in Table 1 within $\mathbf{t_1}$ and sustain the response for $\mathbf{t_2}$. Figure 6 below shows typical expected response. The certified capacity will be in-line with the limits as set out in Table 1.

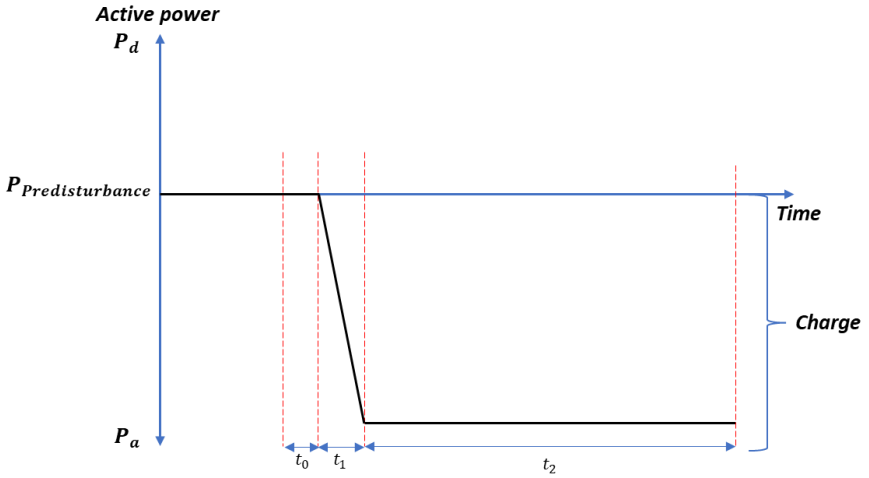

Figure 6: High frequency incidents (BESF response)

Fully Charged

If the BESF is fully charged or if it is operating close to maximum $\mathbf{P_a}$ such that it does not have capacity to absorb during a high frequency event, it shall not change modes to discharging while the system requires absorption from the BESF.

$$\textbf{Maximum } \boldsymbol{P_d} = \boldsymbol{P_d} - \boldsymbol{P_{Predisturbance}} \quad (1)$$

$$\textbf{Maximum } \boldsymbol{P_a} = \boldsymbol{P_a} - \boldsymbol{P_{Predisturbance}} \quad (2)$$

$\boldsymbol{P_{Predisturbance}}$ is the average active power during 3 cycles before the start of the incident. Maximum response is the maximum active power delivered ($\boldsymbol{P_d}$) or active power absorbed ($\boldsymbol{P_a}$) over $\mathbf{t_1}$ after the start of the incident minus $\boldsymbol{P_{Predisturbance}}$. The Sustained response is the average response of the period starting after $\mathbf{t_1}$ and ending at $\mathbf{t_2}$ after the start of the incident, or when the frequency recovers, whichever occurs first. The Average of maximum and sustained (AMS) is calculated using equation 1 below:

Discharging: $$\textbf{AMS Response} = \mathbf{0.5} \times (\textbf{Maximum } \boldsymbol{P_d} + \textbf{Sustained Response}) \quad (3)$$

And

Charging: $$\textbf{AMS Response} = \mathbf{0.5} \times (\textbf{Maximum } \boldsymbol{P_a} + \textbf{Sustained Response}) \quad (4)$$

The resource will be certified based on the average AMS response over all incidents counted in the test period.

4.1.3 Performance Monitoring

The performance of all resources is analysed and reported on. During the first week of every month the **frequency incidents** recorded during the previous month will be analysed to measure the performance of all instantaneous reserve resources, and a report will be sent to all the facilities concerned.

a. Low Frequency Events

A low frequency event is automatically recorded whenever the frequency drops below $\boldsymbol{f_1}$. Sent-out values at a resolution as agreed with SO as provided by EMS are recorded on the relevant SO system for a duration as agreed with SO following each triggered frequency incident.

The facility performance is measured only for low frequency events in which:

- The BESF is contracted for instantaneous reserve.

If the facility's initial sent-out loading is closer to the minimum capacity (fully discharged) or the available reserve capacity is less than the certified instantaneous reserve capacity then the facility is not measured.

Discharge mode

For each low frequency event the maximum response in time $\mathbf{t_1}$ and the sustained response in time $\mathbf{t_2}$ are measured. The average of maximum and sustained response is used to measure the performance as shown in Discharging: $\mathbf{AMS\ Response} = \mathbf{0.5} \times (\mathbf{Maximum}\ \boldsymbol{P_d} + \mathbf{Sustained\ Response})$ (**3**).

If the AMS response is **negative**, it is set to zero. The percentage response for each low frequency event is the AMS response in MW as a percentage of the **certified** capacity.

Charging mode

If the BESF has depleted its storage, it shall ensure that it does not switch mode to charging if the system is still experiencing a low frequency deviation that needs a positive response from the facility.

b. High Frequency Events

A high frequency event is automatically recorded whenever the frequency exceeds the target frequency $\boldsymbol{f_2}$. Sent-out values at a resolution as agreed with SO as provided by EMS are recorded on the relevant SO system for a duration as agreed with SO following each triggered frequency incident.

The facility performance is measured only for high frequency events in which:

- The BESF was contracted for instantaneous reserve.

If the facility's initial sent-out loading is closer to the maximum capacity (full charge) or the available reserve capacity is less than the certified instantaneous reserve capacity, then the facility is not measured.

Discharge mode

If the BESF is fully charged, it shall ensure that it does not switch modes to discharging if the system is still experiencing a high frequency incident that needs a reduction in capacity from the facility.

Charging mode

For each high frequency event, the maximum response in time $\mathbf{t_1}$ and the sustained response in time $\mathbf{t_2}$ are measured. The average of maximum and sustained response is used to measure the performance as shown in equation Charging: $\mathbf{AMS\ Response} = \mathbf{0.5} \times (\mathbf{Maximum}\ \boldsymbol{P_a} + \mathbf{Sustained\ Response})$ (**4**)

If the AMS response is **negative**, it is set to zero. The percentage response for each high frequency event is the AMS response in MW as a percentage of the **certified** capacity.

The average of all percentage responses for both low and high frequency events over the month is the percentage performance of the facility for the month. The facility shall be considered to have performed successfully if the instantaneous reserve performance is greater or equal to the acceptable performance.

4.2 Regulating Reserve

4.2.1 Requirement

BESF contracted to provide Regulating reserve shall respond to EMS automatic instructions within 4 seconds and fully activate required capacity in 1 minute. The purpose of this is to allow for enough capacity to control the frequency and control area tie-lines power within acceptable limits in real time.

Certification

A. Test Period

A test date must be agreed upon between SO and the BESF, at least 10 working days' notice is required. The test will be completed on the agreed test date. If anytime during the test problems are encountered, the test may be postponed. The test will also be postponed if the system conditions do not permit the test to proceed. NC will decide on the day. The BESF will remain "Uncertified" until the certification has been completed.

B. Certification Criteria

Prior to the certification request, all signals required for RR operation must be commissioned with SO. The BESF shall ensure that all pulses are received by their RR equipment successfully. Certification for regulating reserve will consist of the following three tests namely ramp rate test, sustained response test and response delay test.

The following needs to be done before starting the test:

i) RR is switched on the BESF site and at NC.

ii) The facility must be given hourly regulation contracts to mimic how the facility will respond in commercial operation

All the certification tests shall be conducted for both charging and discharging modes

4.2.1.1Ramp Rate Test

NC instructs the BESF to ramp up over the maximum available range to maximum capacity at the minimum ramp rate of 10% of the facility's capacity per minute. This is followed by a ramp down over the same range. The ramp must be done using AGC control.

a. The sent-out level shall be set such that there is enough room to start the test with an up ramp.

b. SO shall ramp the facility using the EMS ramp test facility.
c. When the facility has reached the upper limit, a ramp down shall be initiated to return to the initial position at the rate required.
d. When the ramp is completed, graphs of the test results (ramp up and down with the facility set point and actual generation) will be archived by AS.

4.2.1.2 Sustained Response Test

a. The BESF shall be on RR for at least three consecutive hours for charging mode and three consecutive hours for discharging mode. Tests in each mode do not have to be consecutive.
b. The facility shall respond as required by EMS to provide RR for the test period. Hourly RR data is captured for the test in the relevant SO system(s).
c. To be certified, the facility's average CE must be less than the minimum of 1% of maximum capacity or 5MWh for the following:
    - In charging mode, the BESF shall remain on RR for 3 consecutive hours
    - In discharging mode, the BESF shall remain on RR for 3 consecutive hours

    The facility should be able to remain on RR for all hours during tests without any issues.

4.2.1.3 Response Delay Test

The requested movement (RR pulses) over the time period and the actual sent-out change are analysed from the ramp test data. AS will also analyse data recorded from the four hours (charging and discharging) the facility was operated on RR. To pass the test, the facility shall commence responding to EMS commands within a maximum of 4 seconds since the first EMS command.

Once the facility has satisfactorily completed the three tests above, it will be certified for regulating reserve by the AS and a signed certificate will be sent to the BESF.

4.2.2 Performance Monitoring

Performance of all BESFs is analysed and a report is sent monthly. The facility is monitored on an hourly basis and control error (CE) is measured each hour. The data is used as a performance measurement and for calculation of payments. The hourly data will be available in the relevant SO system(s). Performance calculations shall apply in both discharging and charging modes.

<u>Discharging mode</u>

Whilst in discharging mode the expected response of a BESF is indicated in table below

Discharging mode	**Expected battery response**
Excess generation	• Reduce discharging • Adjust AGC limits accordingly • Eventually stop discharging at low limit • Change to charging mode depending on the state of charge
Generation deficit	• Increase discharging • Adjust AGC limits accordingly, unless minimum state of charge has been reached • Maintain discharging at high limit if generation deficit is still high.

Charging mode

Whilst in charging mode the expected response of a BESF is indicated in table below

Charging mode	**Expected battery response**
Excess generation	• Increase charging • Adjust AGC limits accordingly, unless full charging capacity has been reached • Charge to high limit/full capacity
Generation deficit	• Reduce charging • Adjust AGC limits accordingly • Eventually stop charging at low limit. • Change to discharging mode depending on the state of charge

A. Calculation of Facility Control Error (CE)

The measurement of performance of a facility is based on the general principle that the output of the facility shall follow the setpoint as instructed by AGC. The setpoint sent to the BESF can thus be seen as the current contract from SO for providing regulating reserve. The performance is measured by calculating the closeness of the actual generation to the new dynamic contracted generation including primary frequency support.

Measuring devices used by SO and BESF might have different calibration. There should be no penalties for calibration errors in the output and set point values sent from the BESF to the AGC software module. A calibration error is calculated as shown in equation 2 below. The calculation assumes a perfect response from the BESF and is the average error between contracted setpoint plus primary frequency support and actual generated capacity for each hour:

$$\mathbf{Calibration\ error_{hour}} = \mathbf{average\ capacity_{hour}} - \mathbf{average}\ (\mathbf{contracted\ setpoint} + \mathbf{primary\ frequency\ support})_{\mathbf{hour}} \quad (5)$$

The contracted setpoint is then corrected with this calibration error for every AGC cycle measured. This, together with the required primary frequency support, gives a final BESF supply contract for each cycle as shown in equation 6 below.

$$\mathbf{Supply\ contract_{cycle}} = \mathbf{contracted\ setpoint_{cycle}} + \mathbf{primary\ frequency\ support_{cycle}} + \mathbf{calibration\ error} \quad (6)$$

Actual capacity minus the BESF supply contract will give a facility supply error every AGC cycle as shown in equation 7 below.

$$\mathbf{Supply\ error_{cycle}} = \mathbf{actual\ generated\ capacity_{cycle}} - \mathbf{unit\ supply\ contract_{cycle}} \quad (7)$$

The absolute integral of the facility's $\mathrm{supply\ error}_{\mathrm{cycle}}$ for the hour is then a measure of the performance of the facility, giving a control error in MWh.

$$\mathbf{Control\ error_{hour}} = \mathbf{Integral\ Supply\ error_{cycle}} \quad (8)$$

If the facility's control error is less than 1% of maximum capacity for facilities with capacity less than 500MW or less than 5MWh for facilities with capacity of equal or more than 500MW, then the facility has performed successfully and will be paid for providing the required service.

B. Hourly (real-time) monitoring

NC staff shall monitor the AGC performance in real time. If a facility is found to adversely affect the frequency performance, then the facility may be immediately suspended from AGC. NC shall then inform AS to investigate the cause of the problem and fix it.

AS shall check if facilities bid available for AGC in a given month were actually put on AGC and able to move. If such a facility is contracted for AGC but turns out to be inflexible or not to be on AGC for long periods, then the AGC program will keep sending pulses with no response, leading to poor frequency control. All occurrences of this behaviour will be noted in the monthly report and strongly discouraged. If the ramp rate is set lower by the BESF, for example due to plant instability, NC and AS shall be informed as it should also be changed in EMS.

C. Suspension of a resource from AGC.

SO reserves the right to suspend any facility that is found to compromise the AGC system.

i. If CE is consistently not met or the resource is not responding to control pulses, then it can be suspended with immediate effect.
ii. SO will warn and request the BESF to take the facility off AGC immediately and fix the problem.
iii. If the BESF does not go off AGC, and the problem is not fixed while it continues to offer the resource available for AGC, then the controller in NC may take it off AGC. He will then suspend scheduling of the reserve resource for regulation until the problem is cleared.
iv. After the problem is fixed the BESF shall inform AS in writing. AS will then test the reserve facility and revoke suspension from the next scheduling period onwards.
v. If the problem is found to lie with SO, then SO shall fix the problem within a month from the day the cause of the problem was found.

D. Performance monitoring calculations

The following variables are used to calculate RR performance of a facility:

RR_A = RR availability to ensure required regulating capacity is delivered.

RR_1 = RR performance 1 (CE) to ensure a facility follows the contracted AGC setpoint.

RR_2 = RR performance 2 (Pulses) to ensure at least 90% of requested AGC pulses are responded to

RR Availability ($RR_{A)}$

- Regulating range (hourly) = AGC High limit (Ave hourly) – AGC Low limit (Ave hourly)
- RR availability

  Facility has RR contract (hourly):

$$RR_{AC} = \frac{Average\ of\ regulating\ range\ for\ all\ hours\ on\ AGC\ with\ RR\ contract}{2 * contracted\ Day-ahead\ RRup\ capacity}$$

  Facility has no RR contract (hourly):

$$RR_{AN} = \frac{Average\ of\ regulating\ range\ for\ all\ hours\ on\ AGC\ with\ no\ RR\ contract}{10\% * Facility\ MCR}$$

- Monthly %RR **availability** (RR_A) = average of RR_{AC} and RR_{AN}

RR Performance

(i) Facility performance in %:

RR_1 = 100% - %hours in a **month** where CE is >= minimum of 1% of maximum capacity or 5 MWh)

(ii) Facility performance in %:

RR_2 = 100%, if $(\frac{Total\ acknowledged\ pulses}{Total\ requested\ pulses})$ >= 90%

Requested pulses are a total number of AGC up and down pulses sent from TEMSE to the facility during the hour. Acknowledged pulses are calculated as the minimum between:

- The actual movement (MW change) in the up and down direction found between each 4-second setpoint feedback for the given facility compared to the value before (4 seconds back) summed over the part of the hour the unit is on AGC
- and the requested pulses in the up and down direction.

Else = $(\frac{Total\ acknowledged\ pulses}{Total\ requested\ pulses})$ **over a month**.

(iii) Regulating Reserve Performance **over a month**

= RR_A * RR_1 * RR_2

If the overall facility percentage performance **over a month** is less than 90%, the BESF shall be deemed to have failed to deliver acceptable performance.

4.3 Ten-minute Reserve

4.3.1 Requirement

BESF contracted to provide Ten-minute reserve shall respond and fully activate required capacity within 1 minute when called upon. The purpose of this reserve is to restore instantaneous reserve and regulation reserve to the required levels after an incident. It must be available for at least 2 hours.

4.3.2 Certification

A. Test Period

A test date must be agreed between AS, NC and the BESF. At least 10 working days notice must be given before the actual test. The request shall include the notification mechanism used to start the reserve utilization. A single test will be arranged after all required communication links, notification mechanism and metering are put in place. Testing will continue until at least one successful result is obtained.

B. Test Procedure

The facility shall be required to respond to the notification trigger by discharging or charging to deliver the required power output as per table 1 at the declared ramp rate within 1 minute of the notification by NC and sustaining the response for at least 2 hours as shown in Figure 7. A time delay t_0 (defined in appendix A.3) is expected before a facility can start ramping to the desired output. The facility must be off AGC and IR during the test. The maximum MW response within 1 minute of notification and the average MWs during the time on-line (up to 1 hour) is measured.

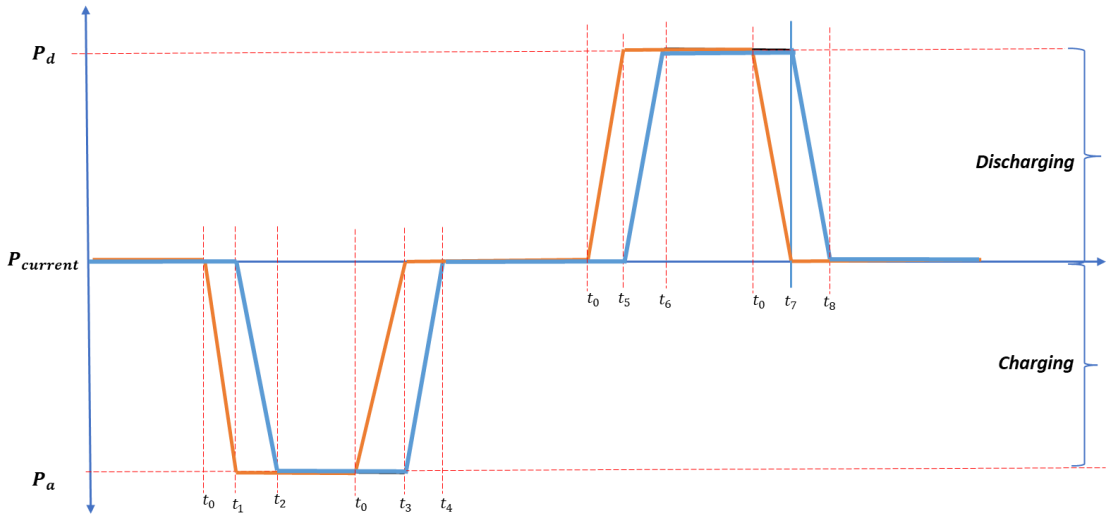

Figure 7: Expected ten-minute reserve response.

Discharging mode

The facility shall be required to respond to the notification trigger by discharging to deliver the required power output at the declared ramp rate within 1 minute of the notification by NC and sustaining the response for at least 1 hour. Whilst in discharging mode the facility shall respond to the dispatch instructions by following a set point signal in both the upward and downward direction as indicated by ramps RR_3 and RR_4 in figure 3. Ramp rates RR_3 (MW/Min) and RR_4 (MW/Min) are calculated as follows:

$$\boldsymbol{RR_3 = \frac{P_d - P_{current}}{t_6 - t_5}} \quad (9)$$

$$\boldsymbol{RR_4 = \frac{P_{current} - P_d}{t_8 - t_7}} \quad (10)$$

The facility must be off AGC and IR during the test. The maximum MW response within 1 minute of notification and the average MWs during the time on-line (up to the 2 hours) is measured. The certified Ten-minute capacity is the AMS response.

Charging mode

The facility -shall be required to respond to the notification trigger charging to deliver the required power output at least the declared ramp rate within 1 minute of the notification by NC and sustaining the response for at least 2 hours. Whilst in charging mode the facility should respond to the dispatch

instructions by following a set point signal in both the upward and downward direction as indicated by ramps RR_1 and RR_2 in figure 3. Ramps RR_1 (MW/Min) and RR_2 (MW/Min) are calculated as

$$\boldsymbol{RR_1} = \frac{\boldsymbol{P_a - P_{current}}}{\boldsymbol{t_2 - t_1}} \quad (11)$$

$$\boldsymbol{RR_2} = \frac{\boldsymbol{P_{current} - P_a}}{\boldsymbol{t_4 - t_3}} \quad (12)$$

The facility must be off AGC and IR during the test. The maximum MW response within 1 minute of notification and the average response during the time on-line (up to the 2 hours) is measured. The certified Ten-minute capacity:

$$\mathbf{TMR} = \boldsymbol{t} \times \frac{\mathbf{RR1+RR2+RR3+RR4}}{\mathbf{4}} \quad (13)$$

Where:
TMR= Certified ten-minute reserve in MW.
t= 1 minute.

4.3.3 Performance Monitoring

- As per NERSA's Scheduling and Dispatch Rules, dispatch instructions shall be issued by NC and logged as resource name, date and time, and expected sent-out or MW response.
- Only facilities contracted for a ten-minute reserve will be measured and performance monitored. This will be based on day ahead hourly reserve contracts.
- The methodology is based on measuring whether the facility achieves its declared ramp rate.

The performance shall be calculated in both charging and discharging modes. The percentage performance over reporting period is based on whether the facility achieves its declared ramp rate. The following parameters are used to calculate ten-minute reserve performance of a facility for a reporting period.

The performance is then calculated as follows:

4.3.3.1 Ramping performance

Hourly ramping performance

Percentage of Ramping Performance in each hour.

$$(RP_{h}) = \frac{(RPU_h + RPD_h)}{2}$$

Where;

RPU_h (Percentage of Ramping up Performance in each hour) =

$$\text{minimum } (\frac{\sum_{i=1}^{nu} RPU_i}{n}, PL), \text{ if } \sum_{i=1}^{h} DPU_i > 0$$

RPU_i (Percentage of Ramping up Performance in a one minute interval) =

$$\frac{APO_i - APO_{i-1}}{DPU_i} \text{ x100\%}$$

$$RPU_h = 1, \text{ if } \sum_{i=1}^{h} DPU_i = 0$$

PL = Over Performance Limit of 110%

APO_i = Average Actual Power Output in MW in a one-minute interval

APO_{i-1} = Average Actual Power Output in MW in a previous one-minute interval

DPU_i = Dispatch up instruction in MW within each hour

RPD_h (Percentage of Ramping down Performance in each hour) =

$$\text{minimum } (\frac{\sum_{i=1}^{nd} RPD_i}{n}, PL), \text{ if } \sum_{i=1}^{h} DPD_i > 0$$

RPD_i (Percentage of Ramping down Performance in a one-minute interval) =

$$\frac{APO_i - APO_{i-1}}{DPD_i} \text{ x100\%}$$

$$RPD_h = 1, \text{ if } \sum_{i=1}^{h} DPD_i = 0$$

DPD_i = Dispatch down instruction in MW within each hour

Overall Ramping performance

Overall Ramping Performance over the billing period is calculated as

$$\mathbf{RP} = \sum_{h=1}^{H} \frac{RP_h}{H} \quad (14)$$

Where:

h = hour in which facility is contracted and dispatched for Ten-minute Reserve

H = Total hours contracted for ten-minute reserve in billing period

4.3.3.2 Control Error Performance (CEP)

Hourly Control Error Performance

Hourly control error performance,

$$\mathbf{CEPh} = \frac{\mathbf{abs}\,(\mathbf{APO_h} - \mathbf{SP_h})}{\boldsymbol{abs}(\mathbf{SP_h})} \quad (15)$$

Where;

$$APO_h = \sum_{i=1}^{900} \frac{APO_i}{900} \text{ , } SP_h = \sum_{i=1}^{900} \frac{SP_i}{900}$$

Where:

APO_h = Average Actual Power Output (in MW) in each hour

APO_i = Actual Power Output (in MW) in time step cycle i

SP_i = Contracted Setpoint Power (in MW), based on issued manual instructions by National Control to change the facility's output in time step cycle i

i = 1 time step cyle of 4 seconds duration within each hour (h)

SP_h = Average Contracted Setpoint Power in each hour.

Overall Control Error Performance

$$\mathbf{CEP} = \mathbf{(1 - \frac{RH}{H})\ x100\%} \quad (16)$$

Where:

CEP = Control Error Performance in billing period
RH = Number of hours where CEP_h is greater than 1%
H = Total hours contracted for ten minute reserve in billing period

If the contracted facility is not dispatched for Ten-minute reserve in a month, its performance will be deemed to have achieved acceptable performance.

4.3.3.3Ten minute performance

Ten-minute reserve performance of contracted facilities shall be determined as follows for both **charging** and **discharging** modes:

PP_{tmr} (Ten minute reserve performance over billing period) = (50%xRP) + (50%xCEP)

The facility shall be considered to have performed successfully if the ten-minute reserve performance is greater or equal to acceptable performance.

4.4 Supplemental Reserve

4.4.1 Requirement

BESF contracted to provide Supplemental reserve shall respond and fully activate required capacity within 10 minutes of a notice being given. To qualify for certification, the facility's response must be sustainable for at least 2 hours. This reserve is not considered as part of operating reserve.

4.4.2 Certification

A. Test Period

The date of the test is arranged between AS, NC and the BESF. A facility that wishes to be certified will submit the data as given in section 5 to AS. At least 10 working days' notice must be given before the actual test. The request shall include the notification mechanism used to start the reserve utilization. A single successful test is required.

B. Certification Criteria

During the test, the BESF is called up by NC and must come on-line and deliver the required capacity within 10 minutes of notification. It shall remain online for at least 1 hour, unless otherwise instructed by NC. The facility's actual capability as tested is taken as the certified capacity.

4.4.3 Performance Monitoring

When BESF in supplemental reserve is called up by the SO, a note will be put in the relevant SO systems. If the facility fails to respond within the agreed notice period, or to remain online for 2 hours (or as long as required by National Control whichever is shorter), the facility is non-compliant. In this case the controller must put a note in the relevant SO system giving the date and time of call-up, the name of the facility and what happened. AS shall inform the BESF about the incident in writing. The BESF must then fix the problem and report back within one month.

Performance of contracted facilities shall be determined as follows for both charging and discharging modes:

$$\mathbf{SR}_m = \sum_{h=1}^{H} \frac{\mathbf{SR_h}}{H} \quad (17)$$

$$\mathbf{SR_h} = \frac{\mathbf{APO_h}}{\mathbf{SP_h}} \quad (18)$$

Where:

SR_m = Supplemental Reserve performance over a month

SR_h = Supplemental Reserve performance over an hour

APO_h = Average Actual Power Output (based on four second data) over an hour

SP_h = Average Contracted Setpoint Power, based on issued manual instructions by National Control to change the facility's output during the hour

h = hour in which facility is contracted and dispatched for Supplemental Reserve

H = Total hours contracted for Supplemental reserve in a month

In the event that the contracted facility is not dispatched for Supplemental Reserve in a month, its performance will be deemed to have achieved acceptable performance.

5. DATA REQUIREMENTS FOR CERTIFICATION

All specified signals shall be made available at the POC by the BESF.

5.1 Instantaneous Reserve Data (400ms)

- BESF name in full
- Maximum sent-out

5.2 Regulating Reserve Data

- BESF name in full
- Maximum sent-out
- Ramp rate up – MW/min
- Ramp rate down – MW/min
- Total range in MW
- CE for each of 6 hours on test (Charging and discharging)

5.3 Ten-minute Reserve Data

- BESF name in full
- Maximum sent-out
- Maximum Pickup in 1 minutes (MW)
- Initial and final sent-out during ramp
- Sustained Response after ramp for period required

TEST SECTION:

- Time of Notification
- Time facility started responding to the instruction
- Time full load first achieved

5.4 Supplemental Reserve Data

- BESF name in full
- Maximum sent-out

TEST SECTION:

- Time of Notification
- Time facility started responding to the instruction
- Time full load first achieved

6. ACCEPTANCE

This document has seen and accepted by:

Name	Designation
I. Fick	General Manager, System Operator
G. Hurford	National Control Manager
L. Du Plessis	National Operations Manager
KC. Masike	Technical Operations Manager
S. Joseph	Ancillary Services Manager
M. Ntusi	Ancillary Services Chief Engineer
M. Gumede	Ancillary Services Chief Engineer
T. Khoza	Grid Code Management Chief Engineer
M. Roets	National Control Services Support Chief Engineer
B.Sibeko	National Operations Chief Engineer
R. Binnerman	National Operations Senior Technologist
M. Soni	Chief Engineer
T. Jacobs	Chief Engineer

7. REVISIONS

8. DEVELOPMENT TEAM

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

Matome Malematja

Musa Gumede

Marathon Ntusi

Ntombi Chavalala

9. Appendix A

A.1 IR Default Time Settings

The table below shows the default value. Each BESF to confirm settings with SO.

Parameter	t_0	t_1	t_2
Time	0	400 ms	10 min

A.2 IR Target Frequency Typical Settings

Below are typical settings for IR.

Parameter	f_1	f_2
Frequency [Hz]	49.5, 49.55, 49.6, 49.65	50.4, 50.45, 50.5

Actual settings to be applied to specific BESF sites shall be provided by SO

A.3 Ten-minute Reserve Default Settings

Time parameter	Time
t_0	To be confirmed with SO
t_2-t_1	1 minute
t_3-t_2	1 hour
t_4-t_3	1 minute
t_6-t_5	1 minute
t_7-t_6	1 hour
t_8-t_7	1 minute

10. Appendix B

Measurement device requirements:

IR (400ms) measurements device requirements		
	IPP BESF	**Eskom BESF**
Measurements device required?	Yes	Yes
Device type	High resolution device	PMU
Data resolution	20 milliseconds	20 milliseconds
Data retention/storage period	6 months	6 months