The South African Grid Code

System Operation Code

Version 9.0

This document is approved by the National Energy Regulator of South Africa (NERSA)

Issued by:

RSA Grid Code Secretariat
Contact: Mr. Bernard Magoro
Eskom Transmission Division, System Operator
P.O Box 103, Germiston 1400
Tell: +27 (0)11 871 2774
Fax: +27 (0)86 663 8418
Email: magorotb@eskom.co.za

Table of Contents

Paragraph No./Title **Page Number**

1. Introduction 5

2. Operation of the IPS 5

2.1 System Operator obligations 5

2.1.1 System reliability and safety 5
2.1.2 System security 6
2.1.3 Agreements for off-site grid supplies to nuclear power stations 7
2.1.4 Operational measures 7

3. Scheduling of generation and ancillary services 8

4. Ancillary services 8

4.1 Operating reserves 9

4.1.1 Instantaneous reserve 9
4.1.2 Regulating reserve 10
4.1.3 Ten-minute reserve 10
4.1.4 Emergency reserve 10
4.1.5 Supplemental reserve 10

4.2 Black start and unit islanding 10

4.3 Constrained generation 11

4.4 Reactive power supply and voltage control from units 11

4.5 Regulation and load following 11

5 Operational authority 11

6 Operating procedures 12

7 Operational liaison 12

8 Emergency and contingency planning 13

9 System frequency and ACE control under abnormal frequency or imbalance conditions 13

9.1 Description of normal frequency or balancing conditions 15

9.2 Operation during abnormal conditions 15

9.3 Power Imports and Exports under abnormal conditions 17

10 Independent action by participants 18

11 Voltage control 18

12 Fault reporting and analysis/incident investigation 18

13 Commissioning 19

14 Risk of trip 20

15 Maintenance co-ordination/outage planning 20

15.1 Outages of generators 20

15.2 Outages of TNSP equipment and associated metering, communication and control facilities that affect IPS operation 20

15.2.1 Responsibilities 20
15.2.2 Outage scheduling process 21

15.3 Co-ordination of outages between TNSP and generators 22
16 Communication of system conditions, operational information and IPS performance 22
17 Telecontrol 22
18 Minimum Primary Fuel Stock Requirements 23
18.1 Coal fired power stations 23
18.2 Gas turbines power stations (liquid fuel) 23
18.3 Hydro power stations 24

1. Introduction

(1) This code sets out the responsibilities and roles of the *participants* as far as the operation of the *interconnected power system (IPS)* is concerned, and more specifically issues related to:

- reliability, security and safety
- *ancillary services*
- market operation actions required by the *System Operator*
- independent actions required and allowed by *customers*
- operation of the *IPS* under abnormal conditions, and
- field operation, maintenance and maintenance co-ordination/outage planning.

2. Operation of the *IPS*

(1) The *System Operator* shall be responsible for the safe and efficient operation of the *IPS*.

(2) The *System Operator* shall operate the *IPS* in accordance with the provisions of the System Operation Code.

(3) All *participants* shall co-operate in setting up operational procedures under the direction of the *System Operator* to ensure proper operation of the *IPS*.

(4) The *System Operator* shall have ultimate authority and accountability for the operation of the *IPS*, in accordance with the conditions of its licence and subject to the provisions of section 5 and section 10.

(5) *SAPP* and other international tie-line operations shall be governed by the *SAPP* and related agreements.

2.1 *System Operator* obligations

The *System Operator* shall be responsible for the following:

2.1.1 System reliability and safety

(1) The *System Operator* shall operate the *IPS* to achieve the highest degree of reliability practicable and appropriate remedial action shall be taken promptly to relieve any abnormal condition that may jeopardise reliable operation. Power transfers as defined in paragraphs (3), (4) and (8) within this section, and other transfers as far as feasible, shall be adjusted as required to achieve or restore reliable *IPS* operation.

(2) The *SO* shall dispatch generation and *demand-side resources* on the *IPS* according to the *scheduling dispatch rules*[1], subject to the constraints of safety of personnel and equipment, *IPS* security, reliability, resource availability, legislation and the environment.

(3) The *System Operator* shall co-ordinate voltage control, operating on the *IPS* and security monitoring on a system-wide basis in order to ensure safe, reliable, and economic operation of the *IPS*.

(4) The *System Operator* shall operate the *IPS*, as far as is reasonable, with sufficient operating reserve capacity to carry its expected load as per the *frequency* control requirements of this code.

(5) During or after a system disturbance, the *System Operator* shall give high priority to keeping all synchronised *units* running and connected to the *IPS*, or *islanded* on their own auxiliaries, in order to facilitate system restoration, as defined in section 4.

[1] Currently being developed

(6) *Black start* services shall be contracted for with at least two suitable facilities to enable the restoration of the power system following the loss of all generation and interconnections with neighbouring countries.

(7) The *System Operator* shall make all reasonable endeavours to retain international interconnections unless it becomes evident that continued parallel operation of the affected parts of the *IPS* would jeopardise the remaining system or damage equipment.

(8) Should it become unsafe to operate *units* in parallel with the system when critical levels of *frequency* and voltage result on the *IPS* from a disturbance, the separation and/or safe shutdown of units shall be accomplished by the *System Operator* in such a way as to minimise the time required to resynchronise and restore the system to normal.

(9) In the event of a system separation, the *System Operator* shall ensure that the part of the *IPS* with a generation deficit shall automatically remove sufficient load to permit early recovery of voltage and *frequency* so that system integrity may be re-established.

(10) The *System Operator* may shed customer load to maintain system integrity. Following such action, customer load shall be restored as soon as possible with due consideration of the possibility of cascading failure or operating at abnormally low *frequency* or voltage for an extended period of time.

(11) An internationally interconnected power system operator may request that the *System Operator* takes any available action to increase or decrease the active energy transfer across the international borders by the way of emergency assistance. Such requests shall be met by the *System Operator* provided it has the capability to do so without jeopardising the network integrity within South Africa.

(12) The *System Operator* shall operate the *IPS* in such a way as to minimise adverse effects of disturbances on *customers*.

2.1.2 System security

(1) The *System Operator* shall operate the *IPS* as far as practical so that instability, uncontrolled separation or cascading outages do not occur as a result of the most severe double contingency. Multiple outages of a credible nature shall be examined and, whenever practical, the *System Operator* shall operate the *IPS* to protect it against instability, uncontrolled separation and cascading outages.

(2) The *auxiliary supply* to nuclear *power stations* (such as Koeberg) shall be considered the most important load on the *IPS*. A *generator* may enter into a detailed agreement with the *System Operator* regarding essential grid supplies for nuclear safety for each nuclear *power station*. The *System Operator* shall cooperate with the relevant *generator* in establishing such an agreement. This agreement shall address the operational limits within which the network is suitable to provide nuclear safety supplies, including

- dynamic and transient stability limits
- voltage stability limits
- steady state limits
- *transmission* connecting equipment reliability.

(3) The *auxiliary supply* to all base-load *power stations* shall be regarded as the second most important load on the *IPS*. The *System Operator* shall regard all essential supplies as identified by the *Distributors* as having the same priority..

(4) The *System Operator* is responsible for efficient restoration of the *TS* after supply *interruptions*.

(5) The *System Operator* shall operate and maintain primary and emergency *control centres* and facilities to ensure continuous operation of the *IPS*.

6) The *SO* shall on a weekly basis evaluate and publish the available generation capacity and primary energy resources required to meet demand over a 52 week planning period.

(7) On or before 30 October of each year, *the SO* shall publish a review (called the "*Medium Term System Adequacy Outlook*") of the adequacy of the *IPS* to meet the long term (5 year future) requirements of electricity consumers.

(8) In preparing the *Medium Term System Adequacy Outlook*", the *SO* must consider:

- the most recent information provided by *generators, embedded generators, NTC, TNSPs* and *distributors*;
- possible scenarios for growth in the demand of electricity consumers;
- possible scenarios for growth in generation available to meet that demand;
- committed projects for additional generation;
- demand management programmes;
- Any other information that the *SO* may reasonably deem appropriate;
- Reasonable assumptions for the imports and exports.

(9) *Participants* shall supply *SO* will all information that the *SO* may require meeting its obligations as defined in this section.

(10) *Generators* and *embedded generators* shall ensure that minimum primary fuel stocks, as prescribed in section 19 below, are available to cater for continuous operation of *power stations*.

2.1.3 Agreements for off-site grid supplies to nuclear *power stations*

(1) The *System Operator* shall, upon request, enter into an agreement as required in section 4.9 of the Network Code.

(2) The *System Operator* shall have back-to-back agreements as applicable with the *TNSP* and/or *distributor* for the provision of off-site supplies to nuclear *power stations*.

(3) The *System Operator* shall provide feedback and illustrate to the *customer,* on an ongoing basis, the status of the integrity of the off-site supply.

(4) All the various *IPS* phenomena that are likely to occur shall be addressed in the off-site supply agreement. Examples of such phenomena that are likely to effect the integrity of the off-site supply, and that need to be addressed are as follows:

- Systems common to a *substation* that are likely to lead to tripping of multiple lines, transformers, reactors, and/or Static Voltage Compensators (SVC)
- Appropriate part system islanding and its associated load shedding and frequency control plans
- Appropriate loading of plant within its specified limits
- Appropriate fault clearing times and associated voltage depressions
- Phase unbalance and waveform distortion
- Sufficient reactive power supply and voltage support
- Sufficient dynamic and transient (first swing) stability margin and the availability of appropriate countermeasures; also provision of adequate protection where required
- Countermeasures and adequate protection for sub-synchronous resonance (SSR)

(5) Where such phenomena are likely to occur, appropriate planning, design, modifications, operation and maintenance of its associated countermeasures and protection systems shall be addressed by the *NTC*. Where practical, countermeasures and/or protection may be provided, maintained and operated by the *customer*.

2.1.4 Operational measures

(1) The *System Operator* shall establish and implement operating instructions, procedures, standards and guidelines to cover the operation of the *IPS* under normal and abnormal system

conditions. The *System Operator* shall maintain a database with version control of all such documents in compliance with license conditions

(2) The *System Operator* shall operate the *IPS*, as far as reasonably possible, within defined technical standards and equipment ratings.

(3) The *System Operator* shall manage constraints on the *TS* through the determination of operational limits and the purchase of the constrained generation *ancillary service*.

(4) The System Operator shall ensure the development, publication and implementation of adequate procedures for the efficient scheduling of generation and network outage as defined in section 15.

(5) To achieve a high degree of service reliability, the *System Operator* shall ensure adequate and reliable communications between *SO* Control Centre and other control centres, power stations and substations. Communication facilities to be provided and maintained by *customers* are specified in the Information Exchange Code.

(6) The *System Operator* shall be responsible for the ongoing determination of the *TS* protection philosophy (as contrasted to equipment protection).

(7) The *System Operator* shall determine, and review where necessary, relay settings for main and backup protection on the *IPS*.

3. *Scheduling* of generation and *ancillary services*

(1) The *SO* shall provide a day-ahead demand forecast for the *IPS*.

(2) The *SO* shall provide the *System Operator* with the daily 24 hours day-ahead energy and *ancillary services* schedule before 14:00 each day.

(3) The responsibility for executing the energy and *ancillary services* schedule shall lie with the *SO*.

(4) The System Operator shall undertake rescheduling on the basis of the scheduling and dispatch rules.

4. Ancillary services

(1) The *System Operator* shall be responsible for the provision of all short-term reliability services for the *IPS*. These include restoration, the balancing of supply and demand, the provision of quality voltages and the management of the real-time technical risk.

(2) The *System Operator* shall certify providers of ancillary services and keep a register of all certified providers.

(3) The *System Operator* shall determine reliability targets for the purposes of acquiring *ancillary services* in consultation with relevant *participants*. The reliability targets shall be selected so as to minimise the sum of the cost of providing the reliability plus the cost to the *customer* of limited reliability. The cost of providing suitable *ancillary service* levels shall be calculated annually for budget purposes.

(4) The *System Operator* shall be responsible for procuring the required *ancillary services* as described in this section in accordance with the license and market rules.

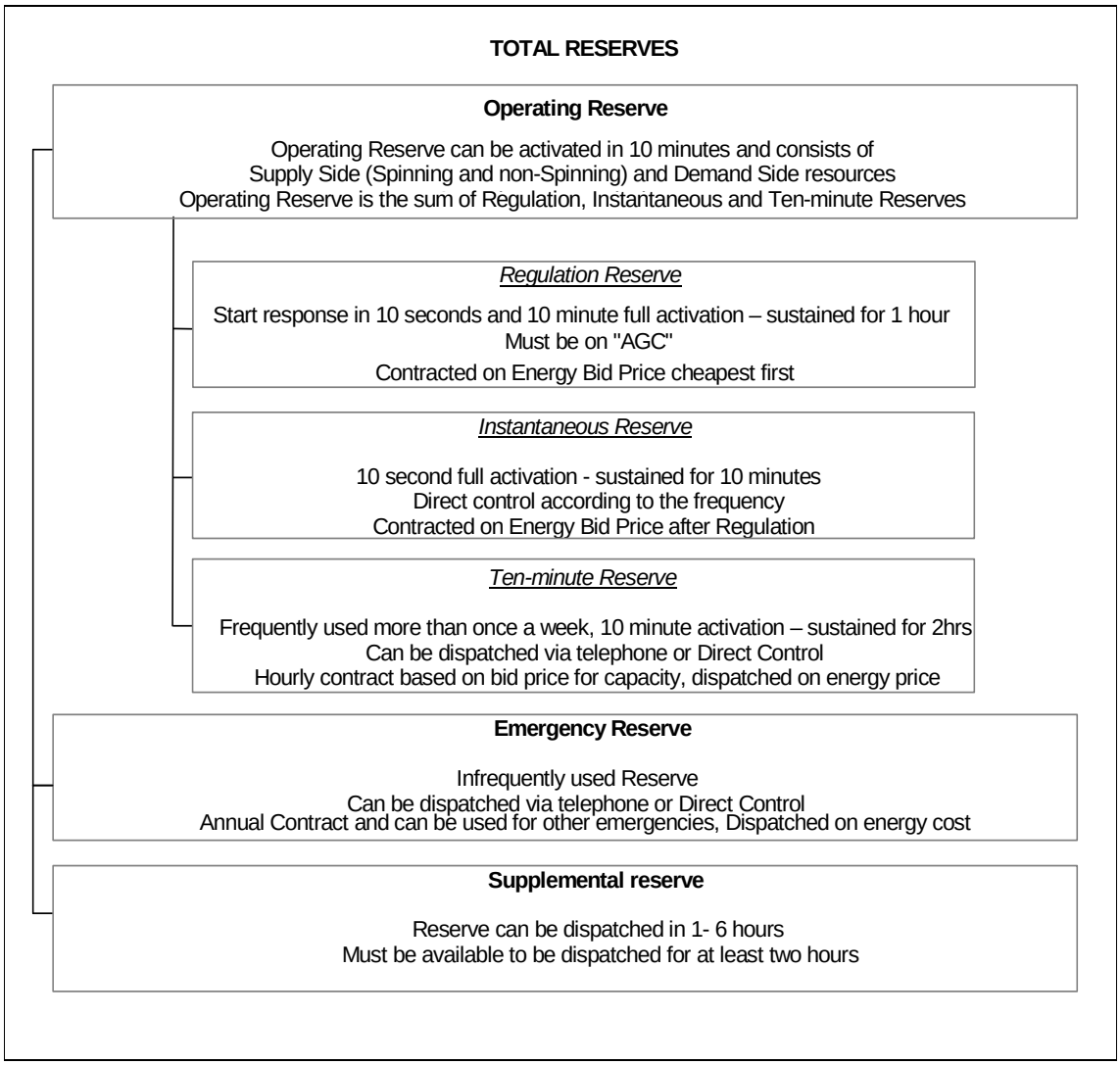
(5) The *System Operator* shall state opportunities for the provision of *ancillary services* as described in the Network Code, section 7.4.

(6) The following services are defined as *ancillary services*:

- Reserves as defined in section 4.1 of this code
- *Black start* and *unit islanding*
- Constrained generation
- Reactive power supply and voltage control from *units*
- *Regulation and load following*

4.1 Operating reserves

(1) Operating reserves are required to secure capacity that will be available for reliable and secure balancing of supply and demand within ten minutes and without any energy restrictions. Operating reserves shall consist of: *instantaneous reserve*, *regulating reserve* and *ten minute reserve*. The total reserve make-up is shown below.



4.1.1 *Instantaneous reserve*

(1) The System Operator shall ensure instantaneous reserve is available as needed to arrest the *frequency* at acceptable limits following a contingency, such as a *unit* trip or a sudden surge in load. A sudden increase in *frequency* is not included as part of *instantaneous reserve*. (Generating *units* are required to respond to high *frequencies* (above 50 Hz) by means of *governing*.)

(2) The requirement on the *System Operator* is to keep the *frequency* above 49.5 *Hz* following all credible single contingency losses. The largest loss is the loss of a Koeberg *unit* at full load, i.e. 920 *MW* (the Cahora Bassa infeed is classified as a multiple incident).

(3) It is also a requirement on the *System Operator* to keep the *frequency* above 49.0 *Hz* after credible multiple contingencies, currently being the loss of 1 800 *MW* generation (typically three coal-fired *units* or the loss of the Cahora Bassa infeed).

(4) Those *generators* that are contracted for Instantaneous Reserve Low Frequencies are also required to provide the capacity for Instantaneous Reserve for high frequencies between the applicable deadband and the 50.5 Hz mandatory requirements as per Network Code, section 3. These *units* are required to respond with at least contracted capacity for low frequencies or according to the agreed droop characteristic. The response is required fully within ten seconds, to an increase in system frequency above the allowable deadband. This response must be sustained for at least ten minutes.

4.1.2 Regulating reserve

(1) *Regulating reserve* is reserve that is under *AGC* and can respond within ten seconds and be fully active within ten minutes of activation. This reserve is used for second-by-second balancing of supply and demand. The reserve is also used to restore *instantaneous reserve* within ten minutes of the disturbance.

4.1.3 *Ten-minute reserve*

(1) *Ten-minute reserve* is required to balance supply and demand for changes between the day-ahead market and real time such as load forecast errors and *unit* unreliability. *Ten-minute reserve* is used to restore *regulating reserve* when required. *Ten-minute reserve* must be activated, on request, within ten minutes and must be sustainable for two hours.

(2) The amount of reserved required is to be calculated by the System Operator and shall be based on SAPP minimum requirements, supplemental and emergency reserve availability, and other reserve considerations.

4.1.4 Emergency reserve

(1) *Emergency reserve* is typically made up from contracted interruptible load, gas turbines and emergency generation (*EL1*).

(2) *Emergency reserve* is a less frequently used reserve and is used when the *IPS* is not in a normal condition and to return the IPS to normal conditions while slower reserves are being activated. The reserve can be used by the *System Operator* for supply and demand balancing, network stability and voltage constraints. This reserve shall be activated, on request, within ten minutes and shall be sustainable for two hours.

4.1.5 *Supplemental reserve*

(1) *Supplemental reserve* is used to reduce the short-term risk. This reserve is available for at least two hours. It is contracted to ensure an acceptable day-ahead risk.

4.2 *Black start* and *unit islanding*

(1) *Islanded units* shall be capable of running in the *islanded* state for at least two hours before re-connecting to the network.

(2) All *units* capable of *unit islanding* are required to contract the service provision to the *System Operator.* The System Operator shall certify *units* capable of *islanding*.

(3) To ensure optimal operation of the *IPS,* the *System Operator* may deploy system *islanding* schemes on the network, e.g. an out-of-step tripping scheme.

(4) The *System Operator* shall determine the minimum requirements for each *black start* supplier and ensure that the contracted suppliers are capable of providing the service.

4.3 Constrained generation

(1) *Constrained generation* is the service supplied by a *power station* to the *NTC* by constraining its power output below (alternatively above) the unconstrained schedule level. The service is required to ensure that the *IPS* remains between appropriate operational limits (e.g. thermal, voltage or stability limits).

(2) In providing the service, the *power station* experiences a financial loss, for which it shall be compensated by the *NTC*, according to the market rules. Constrained generation is required to meet *TS* reliability as there are no current rules for market splitting across *transmission* constraints or the handling of *units* in strategic positions.

(3) The identification of the specific *TS* constraints applicable at any point in time shall be the responsibility of the *System Operator*.

4.4 Reactive power supply and voltage control from *units*

(1) Voltage control and the supply or consumption of reactive power are inter-related in the sense that the voltage is affected by changes in the reactive power flow. System stability depends on the voltage profile across the system. In view of these considerations it is necessary from time to time to employ certain *power stations* to supply or consume reactive power, provided that the *unit* is not required to operate outside of its *effective capability diagram* referred to in section 3.1.3 (5) of the Network Code, for the purpose of voltage control.

(2) The *System Operator* shall control the amount of reactive power. This may be done directly through the energy management system or by telephone.

(3) When a *unit* is generating or pumping, reactive power supply is mandatory in the full operating range as specified in the Network Code, section 3.1.3.

4.5 Regulation and load following

(1) This service is the automatic matching of supply and demand in real time by increasing or decreasing the active power of *units*. The control system for this is called automatic generation control (*AGC*) and it can send a command, to increase or decrease real power output when signalled to do so.

(2) The resources contracted by the *System Operator* for this service shall operate under *AGC* control and shall be able to alter their generation or load under direct control of *AGC* to the performance requirements specified by the *System Operator*. The requirement for the total capacity of regulation to be provided by the suppliers of this service is specified under *regulation reserve*. This requirement is to meet the *frequency* and tie-line control standards as defined by the *System Operator an*d the *SAPP*.

5 Operational authority

(1) The *System Operator* shall have the ultimate authority to instruct operating on the *TS*. Operational authority for other networks shall lie with the respective asset owners.

(2) The *System Operator* shall enter into operating agreements with each *TNSP* for safe and efficient operating of the *TNSP* network.

(3) Network control, as it affects the interface between a *TNSP* and a *customer*, shall be in accordance with the operating agreements between the *participants*.

(4) Except where otherwise stated in this code, no *participant* shall be permitted to operate the equipment of another without the permission of such other *participant*. In such an event the asset owner shall have the right to test and authorise the relevant operating staff in accordance with its own standards before such permission is granted.

(5) Notwithstanding the provisions of section 2.1, *participants* shall retain the right to safeguard their equipment.

6 Operating procedures

(1) The *System Operator* shall develop and maintain operating procedures for the safe operating of the *TS*, and for assets *connected to the TS,* as per section 2.1.4. These operating procedures shall be adhered to by *participants* when operating equipment on the *TS* or connected to the *TS.*

(2) Each *customer* shall be responsible for his own safety rules and procedures at least in compliance with the relevant safety legislation. *Customers* shall ensure that these rules and procedures are compatible with the *System Operator* procedures defined in paragraph (1).

(3) The *SAPP* operating agreements shall apply in the case of operational liaison with all international power systems connected to the *TS*.

(4) *Customers* and *service providers* shall enter into operating agreements as defined in the *service provider* licenses.

7 Operational liaison

(1) The *System Operator* shall sanction the shutting down and synchronising of *units*.

(2) If any *participant* experiences an emergency, the other *participants* shall assist to an extent as may be necessary to ensure that such emergency does not jeopardise the operation of the *IPS* or health of plant.

(3) In the event that it is physically possible for a *customer* to transfer load or *embedded generators* from one *point of supply* to another by performing switching operations on the *customer's* network, the operating agreement shall cover at least the operational communication and notice period requirements, and switching procedures for such load transfers.

(4) The *TNSP*, in consultation with a specific *generator*, shall compile both a comprehensive maintenance philosophy, and a test and inspection plan for all equipment, systems and schemes installed in the specific *HV yards*, addressing concerns from both *parties*.

(5) The *TNSP* shall provide notification to *generators* of any work to be performed on any *VT* and/or *CT* circuits in *HV yards*, protection schemes or functions of *HV yards*. The *TNSP* will compile recommissioning programmes for such work in consultation with the *generator.*

(6) The *TNSP* and *customers* shall agree on the busbar configuration(s) at each *point of supply* during normal and emergency conditions. Details of such configuration(s) shall be included in the operating agreement between the *participants*.

(7) *Generators* shall inform the *System Operator* of any environmental limitations that would affect the dispatch of the plant.

8 Emergency and contingency planning

(1) The *System Operator* shall develop and maintain contingency plans to manage system contingencies and emergencies that are relevant to the performance of the *IPS*. Such contingency plans shall be developed in consultation with all *participants*, as per section 2.1.4, shall be consistent with internationally acceptable utility practices, and shall include but not be limited to

- under-*frequency* load shedding
- meeting *SATEPSA* disaster management requirements including the necessary minimum load requirements
- *forced outages* at all points of interface, and
- supply restoration.

(2) Emergency plans shall allow for quick and orderly recovery from a partial or complete system collapse, with least cost solution and minimum impact on *customers*.

(3) The *System Operator* shall periodically verify contingency and/or emergency plans by actual tests to the greatest practical extent possible. In the event of such tests causing undue risk or undue cost to a *participant*, the *System Operator* shall take such risks or costs into consideration when deciding whether to conduct the tests. Any tests shall be carried out at a time that is least disruptive to the *participants* and embedded *end-use customers*. The costs of these tests shall be borne by the respective asset owners. The *System Operator* shall ensure the co-ordination of the tests in consultation with all affected *participants*.

(4) The *System Operator* shall specify minimum emergency requirements for *distributor control centres*, *power station* local *control centres* and *substations* to ensure continuous operation of their control, recording, annunciator and communication facilities.

(5) Other *participants* shall comply with the *System Operator's* reasonable requirements for contingency and emergency plans.

(6) The *System Operator* shall set the requirements for automatic and manual load shedding. *Participants* shall make available loads and schemes to comply with these requirements.

(7) The *System Operator* shall be responsible for determining all operational limits on the *TS*, updating these periodically and making these available to the *participants*.

(8) The System Operator shall conduct load flow studies regularly to determine the effect that various component failures would have on the reliability of the *IPS*. At the request of the *System Operator*, *distributors* shall perform related load flow studies on their part of the network and make the results available to the *System Operator*.

9 System *frequency* and *ACE* control under abnormal *frequency* or imbalance conditions

(1) The *System Operator* shall be responsible for the balancing of supply and demand in real time through the implementation of the energy schedules and utilisation of *ancillary services*.

(2) Frequency shall be controlled according to quality criteria as defined by *NRS 048* and Southern African Power Pool requirements

(3) Figures 1(a) and (b) summarise the governor and load shedding requirements for low and high frequency control as required by the system operator.

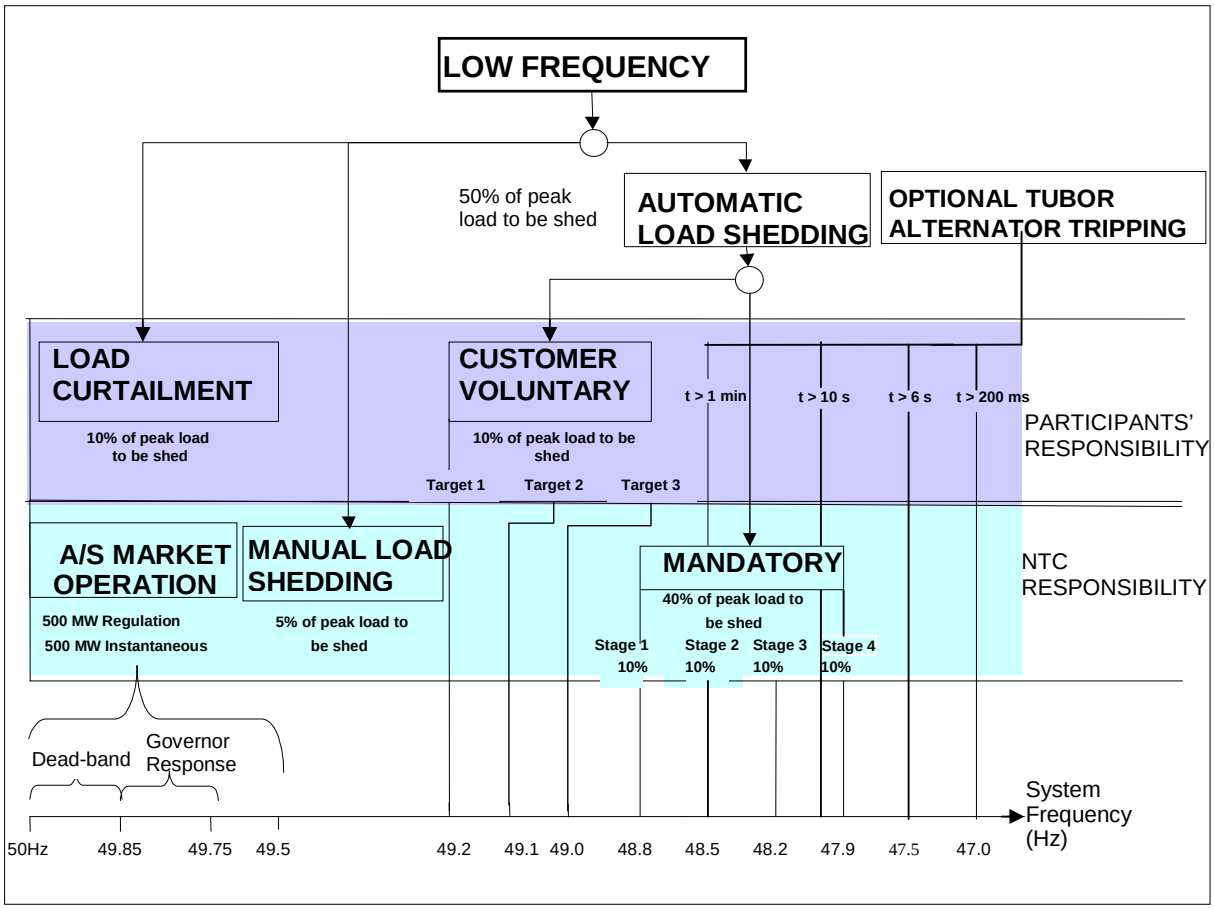


Figure 1(a): Low frequency requirements

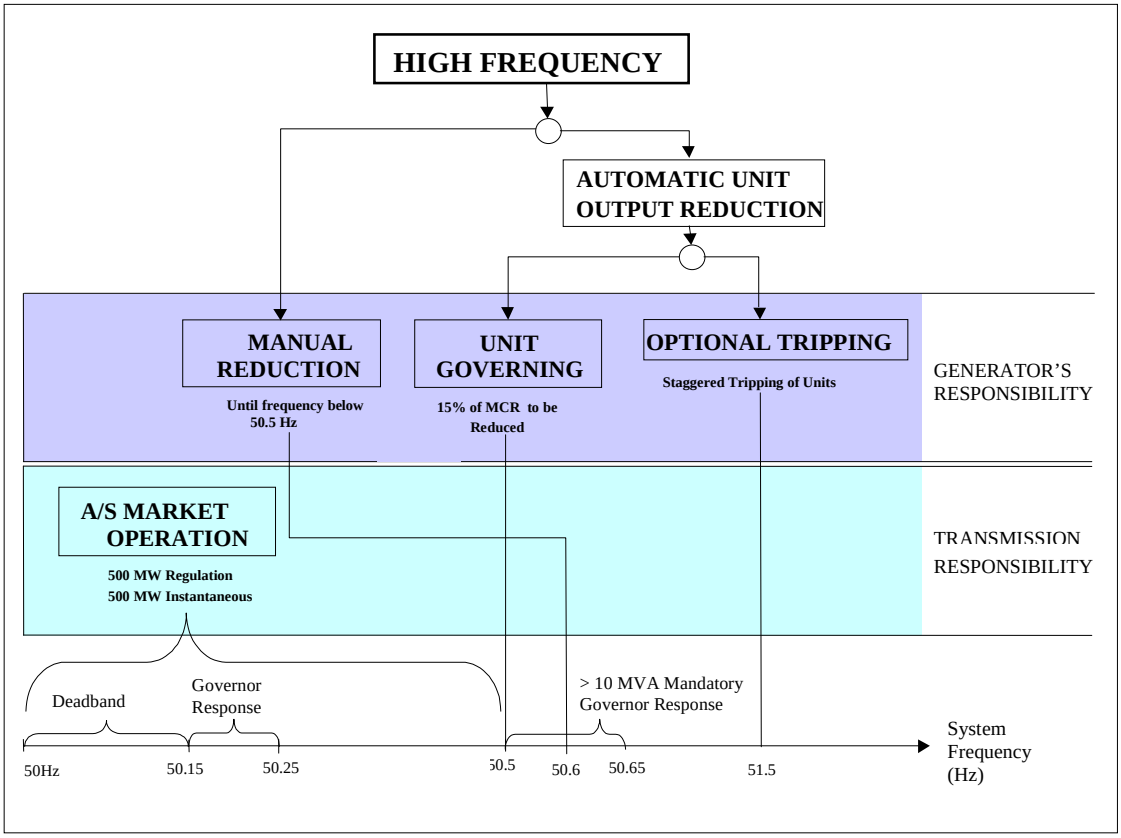


Figure 1(b): High frequency requirements

9.1 Description of normal *frequency* or balancing conditions

(1) The *control area* is considered to be under normal *frequency* conditions when

- the immediate demand can be met with the available scheduled resources, including any expensive contingency resources; and
- the *ACE* deficit does not exceed the available reserves for longer than 10 minutes; and
- the frequency is not less than 49.8 Hz for longer than 10 minutes; and
- the frequency is within the range 49,5 to 50,5 *Hz*; and
- the interconnections are intact; and
- there are no security and safety contraventions.

(2) The *control area* is considered to be under abnormal conditions if it is not in a normal condition as defined above.

9.2 Operation during abnormal conditions

(1) When abnormal conditions occur, corrective action shall be taken as stipulated in table 1, until the abnormal condition is corrected.

Table 1 Operation during abnormal conditions

CONDITION FOR USAGE	RESOURCES IN DEFAULT ORDER OF USAGE
Warnings	
When a shortfall in supply is expected to occur, issue warnings in sequence until sufficient capacity is obtained to cover the shortfall	*EL1* generation warning Interruptible load shedding warning
Generation deficit foreseen with gas turbine operation and load shedding expected	Warning to municipalities Warning to SAPP members
i) Deficit of 2.5% expected with all generation at maximum and all possible municipal assistance in operation, excluding municipal gas turbines ii) F < 49,7 Hz and expect F < 49,5 Hz for longer than two hours	***Load reduction warning*** Warning to SAPP members
Gradual frequency decline – refer to merit order in control room for order of use	
CONDITION FOR USAGE	**RESOURCES IN DEFAULT ORDER OF USAGE**
If frequency falls below 50 Hz and an abnormal condition exists, the *System Operator* shall apply resources in the order most suitable to ensure system security depending on the conditions existing at the time	Run all available plant at *MCR* Dispatch emergency capacity according to *System Operator* merit order, such as: • *EL1* generation • *SAPP* non-firm sales • unscheduled hydro • contracted *interruptible load* • *SAPP emergency* energy • gas turbines
F<49,5Hz and expect load shedding or curtailment	Mutual standby assistance from municipalities including municipal gas turbines
i) Sufficient advance notice available and expect F < 49,2 Hz All emergency measures introduced except municipal gas turbines ii) F < 49,5 Hz for > 1 hour is expected	Load curtailment
i) Immediate load reduction required, expect f < 49,2 Hz after all emergency measures introduced except municipal gas turbines ii) F < 49,2 Hz for 15 minutes iii) F < 49,0 Hz immediately	Load shedding
F<49,1 Hz with all other emergency measures introduced in the time available	Municipal gas turbines
Rapid *frequency* decline - Automatic operation by under-*frequency* relays – apply in order	
CONDITIONS FOR USAGE	**RESOURCES IN ORDER OF USAGE**
1. F < 49,5 Hz	1. Abnormal condition exists
2. F < 49,5 Hz for 10 seconds	2. Pumped storage start (including pump load shed) Interruptible contracted load shed (after pumped storage) Manual load shed
3. F < 49,4 Hz for 20 seconds	3. Gas turbine start and emergency reserve market
4. F < 49,2 Hz for 0,3 seconds F < 49,1 Hz for 0,3 seconds	4. Voluntary u/f load shedding 1 Voluntary u/f load shedding 2 Voluntary u/f load shedding 3

F < 49,0 Hz for 0,3 seconds 5. F < 49,0 Hz for 0,5 seconds 6. F < 48,8 Hz for 0,5, 1,2, 2 seconds F < 48,5 Hz for 0,5, 1,2, 2 seconds F < 48,2 Hz for 0,5, 1,2, 2 seconds F < 47,9 Hz for 0,5, 1,2, 2 seconds	5. Tie-line trips 6. Mandatory u/f load shed – stage1 Mandatory u/f load shed – stage2 Mandatory u/f load shed – stage3 Mandatory u/f load shed – stage4
***Frequency* restoration after rapid decline**	
CONDITIONS FOR USAGE	**RESOURCES IN ORDER OF USAGE**
1) By *units*: F < 49,4 Hz (low-*frequency* alarm at *power station*) F > 50,6 Hz (high-*frequency* alarm at *power station*)	 If no contact with the *SO* and low-frequency alarm, increase generation either to *EL1* or until F > 49,5 Hz If no contact with the *System Operator* and high-frequency alarm, decrease generation either to minimum constraint requirement of system operations or until F < 50,5 Hz
2) By the *System Operator*	Take restoration action as soon as possible after U/F relays have operated
Prolonged capacity deficit – Durations	
CONDITIONS FOR USAGE	**RESOURCES IN ORDER OF USAGE**
Emergency reserve – as per contracts ***Gas turbines – continuous*** Mutual standby – continuous Load reduction/shedding – as short as possible Municipal gas turbines - 1 hour in any 4-hour period	

(2) The corrective action includes both supply-side and demand-side options. Where possible, warnings shall be issued by the *System Operator* on expected utilisation of any contingency resources.

(3) Subject to conditions of table 1, the order in which each category of *emergency resources* such as load shedding, *emergency generation* and gas turbines are to be used may be rotated, based on contractual arrangement. The *System Operator* shall issue an updated list.

(4) Termination of the use of emergency resources shall occur as the plant shortage situation improves and after *frequency* has returned to normal.

(5) During emergencies that require load shedding, the request to shed load shall be initiated in accordance with agreed procedures prepared and published by the *System Operator*.

(6) Automatic under-frequency systems shall be kept armed at all times, apart from gas turbines, which shall be armed by the *System Operator* when a shortage is expected.

9.3 Power Imports and Exports under abnormal conditions

(1) The *SO* shall manage power exports and imports according to the *SAPP* rules, the relevant supply contracts and the requirements of the *IPS*.

(2) Non-firm power export contracts (as defined in the *SAPP* Operating Agreements) shall be curtailed during sustained *abnormal situations*.

(3) Proportional manual *load curtailment* shall be required of all regional utilities in the South African control area. The proportion shall be determined based on their actual off-take from the South African network (*NIPS*)

(4) *Load shedding* and *load curtailment* of *end-use customers* (non-utilities) with contracts for the supply of electricity in neighboring countries shall be applied on an equal footing to such *customers* in South Africa.

(5) During sustained *abnormal situations*, contractual capacities shall be reduced in line with capacity and energy reductions required of South African *customers* to manage the *abnormal situation*.

10 Independent action by *participants*

(1) Each *participant* shall have the right to reduce supply or demand, or disconnect a *point of connection* under emergency conditions, if such action is necessary for the protection of life or equipment. Each participant shall give advance notice of such action where possible. Examples include hot connections, solid breakers, malfunctioning protection, etc.

(2) During *customer* emergencies that require load shedding, the request to shed load shall be initiated in accordance with agreed procedures prepared and published by the *System Operator*.

(3) Independent action may be taken for nuclear *units* licensed by the National Nuclear Regulator, in terms of the National Nuclear Regulatory Act (Act 47 of 1999).

(4) Following such emergency operations as may be necessary to protect the integrity of the *IPS* or the safety of equipment and human life, the *participants* shall work diligently towards removing the cause of the emergency and the supply shall be reconnected immediately after the emergency conditions have passed.

11 Voltage control

(1) The *System Operator* shall be responsible for the voltage control of the *TS*, the *substations* of the *NTC* and all other *networks* agreed to with *customers*.

(2) The *System Operator* shall operate, under normal operating conditions, in accordance with section 4.14 of the Network Code.

(3) Electricity shall be supplied at three-phase alternating current which shall have a declared voltage between defined limits, at the *points of supply*, as agreed between the *participants* in the operating agreement.

(4) *TS* voltages shall be controlled during normal operation to be at least within statutory limits at the *points of supply* and otherwise as agreed with customers.

(5) Voltages shall not deviate by more than 5% from the declared voltage under normal operating conditions for any two ten-minute periods within a calendar year, except where otherwise agreed between *participants*. Normal operating condition is defined as a state where no network component on the affected part of the TS is out of service due to a *forced outage* beyond the control of the system operator or due to a *planned outage*.

12 Fault reporting and analysis/incident investigation

(1) *Generators* shall report loss of output and tripping of *units* and change of status of *AGC* and *governing* to the *System Operator* within 15 minutes of the event occurring.

(2) In the event of an *MUT*, the relevant *generator* shall take the following action:

- The *generator* shall submit a written report to the *System Operator* within one month for any multiple unit trip that could in future cause a category 1 or 2 trip, identifying the root causes of the incident and the corrective actions taken.
- Category 2: generator shall provide a full report as per Network Code, section 3, and this shall be treated as a major incident.

(3) *Distributors* and *end-use customers* shall report the loss of major loads (>100MW) to the *System Operator* within 15 minutes of the event occurring. Warning of the reconnection of such loads shall similarly be given with at least 15 minutes' advance notice.

(4) Incidents on the *IPS* involving sabotage or suspected sabotage, as well as threats of sabotage, shall be reported to the *System Operator*.

(5) The *NTC* shall investigate any incident that materially affected the quality of the service to another *participant*. These include *interruptions of supply*, disconnections, under or over voltage or frequency incidents, quality of supply contraventions, etc. A preliminary incident report shall be available after three working days and a final report within three months. The *NTC* shall initiate and co-ordinate such an investigation, arrange for the writing of the report and involve all affected *participants*. All these *participants* shall make all relevant *information* available to the *NTC* and participate where reasonably required. The *NTC* shall make the report available to any requesting participant within the confidentiality constraints.

(6) Any *participant* shall have a right to request an independent audit of the report, at its own cost. If these audit findings disagree with the report, the *participant* may follow the dispute resolution mechanism. If the audit agrees with the report, the report recommendations shall stand.

(7) Recommendations that require a change in the *Grid Code* shall be submitted to the review process as defined in the Governance Code. Such recommendations shall only be implemented upon approval of the amendment.

(8) All other recommendations shall be implemented by the *participants* within the time frames specified

13 Commissioning

(1) The *System Operator* shall verify commissioning / maintenance programmes concerning operating at *IPS substations* as far as is needed to ensure adequate co-ordination and reliability of the *IPS*.

(2) All significant aspects of commissioning, by *customers* or *TNSPs,* of new equipment associated with the *transmission* system, or re-commissioning of such existing equipment, shall be agreed in writing with the *System Operator,* acting reasonably, before such commissioning starts.

(3) The said aspects may include, but not be limited to the following:
- Commissioning procedures and programmes
- Documents and drawings required
- Proof of compliance with standards
- Documentary proof of the completion of all required tests
- *SCADA information,* to be available and tested before commissioning
- Site responsibilities and authorities, etc.

(4) Participants shall give minimum notice of one month, unless otherwise agreed, from the date of receipt of the request for all commissioning or re-commissioning. Where commissioning is likely to involve a requirement for dispatch and/or operating for test purposes, the *participant* shall notify the *System Operator* of this requirement, including reasonable details as to the duration and type of testing required.

(5) When commissioning equipment at the *point of connection* , the *TNSP* shall liaise with the affected *customers* on all aspects that could potentially affect the *customers'* operation.

(6) Pursuant to clause 13 (1) and (2), the *TNSP* or *customers* shall perform all commissioning tests required in order to confirm that the plant and equipment meets all the requirements of the *Grid Code* that have to be met before going on-line. The *System Operator* may request relevant tests (or results of such tests) to be demonstrated in accordance with this Code before accepting such plant for operating.

14 Risk of trip

(1) *Generators* shall identify and report all *MUT* risks to the *System Operator*.

(2) *Participants* shall minimise to the extent reasonably practical and economic, the risk of tripping/loss of output on their own plant and equipment, associated with their operation and maintenance.

(3) Special care shall be taken by all *participants* when planning or executing work on protection panels, by introducing a review step in the planning of work process. The outage process described in the maintenance co-ordination/outage planning section shall be followed. The System Operator shall treat all such work as *risk-related outages.*

(4) There are two types of risk of trip (ROT), namely scheduled and unscheduled.

(5) The scheduled ROT is typically associated with secondary equipment, such as testing of a protection scheme. A *participant* shall request the risk of trip in advance and it is subject to acceptance by the *System Operator*. The *System Operator* has the right to refuse work associated with such a request based on system conditions and reschedule.

(6) The unscheduled ROT is typically associated with primary equipment, e.g. a generator tube leak. In such a case it is compulsory for the *participant* to inform the *System Operator* of the risk event and of the plant status, within 15 minutes of the risk being identified, for plant exceeding a 100 MVA rating.

(7) When an ROT of equipment or loss of output could occur on any part of the *IPS*, the affected *participants* shall be informed and shall acknowledge the ROT.

(8) The asset owner shall inform the *System Operator*, and the *System Operator* shall in turn inform other affected *participants* when the risk has been removed.

15 Maintenance co-ordination/outage planning

(1) Optimal operation of the *IPS* shall be achieved by the *System Operator* co-ordinating scheduled *outages* of *generators*, equipment of the *TNSPs*, and associated metering, communication and control facilities that affect *IPS* operation

15.1 Outages of *generators*[2]

15.2 Outages of *TNSP* equipment and associated *metering*, communication and control facilities that affect *IPS* operation

15.2.1 Responsibilities

(1) It is the responsibility of the *participant* requiring the *outage* on plant for planned maintenance, repairs, auditing, emergency repairs, construction, refurbishment, projects, inspection, testing or to

[2] Currently being developed at part of the Scheduling and Dispatch Rules

provide safety clearance for other activities such as servitude clearance, line crossings and underpasses to request the *outage* from the *TNSP*.

(2) The *TNSP* shall ensure that where there are more than one outage request per bay, within a specific time period, the *parties* involved, shall where possible combine the outages into a single outage of the same piece of plant. If another *outage* request for the same bay(s)/plant is noticed within an acceptable time period, the *TNSP outage* scheduler shall request the *parties* involved to combine their requests into a single *outage*. In the case of conflicting *outages* (simultaneous *outages* which may increase the risk of loss of supply to a *substation* or area), the *TNSP outage* scheduler shall consider the priority and relative urgency of the requests and reflect this against the validated request. The *TNSP outage* scheduler is also responsible for ensuring that necessary resources are available for the outage and that negotiations of *risk-related outages* have taken place with relevant stakeholders. The *TNSP outage* scheduler is responsible for ensuring that the requested outages can physically be executed from a plant perspective.

(3) The *System Operator* shall appoint an *outage* scheduler to assess the viability of a scheduled *outage* and either to allow or turn down the request. This scheduler shall optimise plant utilisation by evaluating network and *generation* capabilities, different system configurations and risk factors. It is also the responsibility of the scheduler to co-ordinate and schedule plant that affects international customers.

(4) The *System Operator* shall in real time be responsible for finally sanctioning (or alternatively refusing) an *outage* and ensuring that the relevant operating instructions are issued.

.

15.2.2 *Outage* scheduling process

(1) When the need for an *outage* is first identified, it shall be requested by the *TNSP*.

(2) The *TNSP* shall optimise the *outages* for which it is responsible in terms of resources and minimising risk, and ensure that necessary resources are available and that *customer* negotiations have taken place.

(3) *Outages* shall be negotiated by the *TNSP* with *customers* and then booked at least 14 days prior to the date of outage. Planned interruptions should be negotiated with relevant parties at least 35 days prior to the interruption.

(4) The *TNSP* shall ensure that the relevant contingency plans are in place and are updated as required. The contingency plans will include but not be limited to

- Re-configuration of the network and security linking prior to or during an outage to ensure minimal risk to customers
- Re-configuration of the network after a further contingency to optimise system security and *customer* restoration
- Returning the plant that is on *outage* back to service as soon as possible
- Restoring supply to *customers* by utilising by-pass schemes
- Load shedding if necessary (load profiles shall be made available by the *customer*)
- Listing of contact persons.

(5) During the development of the contingency plans, the following responsibilities are realised:

- The *System Operator* and relevant *distributor* control centres shall be responsible for the security linking instructions in the said contingency plan.
- It shall be the responsibility of the *TNSP* to supply the information related to returning the plant to service.
- The *TNSP* shall develop by-pass schemes with assistance from the *System Operator* and the customer control centre.
- The *System Operator* and relevant *distributor* control cent*res* shall be responsible for identification of the load at risk and load shedding in the said contingency plan.

(6) The *System Operator* shall assess the risk associated with the *outage*. If there is no unreasonable risk posed to *IPS* parties or if he is satisfied that adequate information regarding the risk has been communicated to *customers*, the *outage* will be allowed to go ahead.

(7) The *System Operator* shall publish an updated *outage* schedule on a weekly basis for a rolling month ahead. This will reflect the status of all booked outages.

(8) Conflicting *outages* shall be negotiated between the various parties concerned and optimised according to risk and financial impact.

(9) The *System Operator* has, in real time, the final right of veto or sanction of an *outage*, based on the state of the network at the time the *outage* is to be taken and any other risks which may be envisaged for the duration of the *outage*.

15.3 Co-ordination of *outages* between *TNSP* and *generators*

(1) Certain *outages* will affect both the *TNSP* and *generators*. Examples include busbars, links and lines emanating from *power stations*. As far as possible, *TNSP outages* will be planned to coincide with the *generator outages* due to the financial impact associated with constraining *generators* off or moving *generation outages*.

(2) This will not apply to emergency or forced *outages*. *Generators* are required to adhere to their planned *outage* dates and may only deviate from their plan with agreement from the *System Operator*.

(3) Optimal reliability of the *IPS* shall be achieved by the *System Operator* co-ordinating scheduled outages of *generators*, *TNSP's*, *distributors*, *end-use customers*, and associated metering, communication and control facilities affecting *IPS* operation.

16 Communication of system conditions, operational information and *IPS* performance

(1) The *System Operator* shall monitor and/or determine system conditions from time to time, and communicate these, or changes from a previous determination, to all *participants*.

(2) The *System Operator* shall be responsible for providing *participants* with operational *information* as may be agreed with the affected participants. This shall include information regarding *planned and forced outages* on the *IPS* as determined by the market rules.

(3) The *System Operator* shall inform participants of any network condition that is likely to impact the short and long-term operation of that participant.

(4) The System Operator shall timeously communicate any changes or modifications to the *TS* to the relevant participant.

(5) The *System Operator* shall report on both technical and energy aspects of *IPS* performance monthly and annually. This reporting shall include daily demands, energies, losses, interruptions and *QOS* aspects as detailed in the Information Exchange Code. This information shall be available to all *participants* on request.

(6) The *System Operator* shall annually publish expected fault levels, including the rupturing capacity of relevant *NTC* equipment, for each *point of supply*.

17 Telecontrol

(1) Where telecontrol facilities are shared between the *System Operator* and other *participants*, the *System Operator* shall ensure that operating procedures are established in consultation with the participants.

18 Minimum Primary Fuel Stock Requirements

(1) In order to mitigate against fluctuations in the supply chain of primary fuel to the power stations (*PS), generators* and *embedded generators* shall maintain, in the on-site stock holding facility, the primary fuel stock, which shall be maintained at or above the minimum fuel stock levels prescribed in this section. For gas turbines, an off-site stock holding facility may be utilised subject to approval (concurrence) by *SO*.

(2) Each *generator* and *embedded generator* shall provide to the *SO*, in an agreed template, a weekly report of actual primary fuel stock available in the stock holding facility at each *PS*.

(3) *Generators* and *embedded generators* shall prepare emergency recovery plans aimed at returning fuel stock levels to minimum levels within a reasonable time frame when primary fuel stock level fall below the minimum levels prescribed in this code. The recovery plan and all changes thereto shall be made available to the SO for review. There need to be concurrence from SO that the plans are adequate.

(4) When a *PS* fails to meet the minimum fuel stock level, the relevant *generator* or *embedded generator* will inform the *SO* and provide a revised forecast of coal stock with contingency plans. In addition, the *generator* or *embedded generator* shall inform the *SO* daily on the amount of fuel stock available in the holding facility.

(5) If in the reasonable assessment by *SO* given the information available to it, there is a significant risk to the system due to probable primary fuel supply risks that may negatively impact security of electricity supply, the *SO* shall inform *NERSA* .

(6) The *Generator* or *embedded generator* shall determine the target and alarm levels for primary fuel stock in order to meet the minimum primary fuel stock levels prescribed in this section.

(7) The actual available primary fuel stock estimates shall be determined by generator or embedded generator for each *PS*, taking into account factors such as historical usage, production forecasts, maintenance plans, plant reliability, reasonable assumptions on the use of ancillary services, relevant plant modifications and other reasonably foreseeable risks.

(8) The minimum fuel stock levels that should be available at each *PS* at all times are as described below:

18.1 Coal fired power stations

(1) All coal fired power stations first commissioned after 1970 shall have an equivalent of 20 days coal burn at 80% MCR of all units that have been declared commercial and that is not on forced or planned outage.

(2) All coal fired power stations first commissioned prior to 1970 shall have an equivalent of 10 days coal burn at 80% MCR of all units that have been declared commercial and that is not on forced or planned outage

(3) Should a PS fails to meet the minimum fuel stock level as specified above, the relevant generator or embedded generator will inform the SO and provide a revised forecast with contingency plans. In addition, the generator or embedded generator shall inform the SO daily on the amount of fuel stock available in the holding facility.

18.2 Gas turbines power stations (liquid fuel)

(1) Each gas turbine *PS* shall have a minimum on-site fuel storage capacity equivalent to 24 hours of continuous operation of all units at *MCR*. An alternative (off-site) storage facility of the same

amount can be utilised, provided fuel supply to the *units* can be made available immediately. Such alternative storage facility is subject to the reasonable approval by the *SO*.

(2) Depending on IPS requirements the SO may, at design phase and acting reasonably, request the generator or embedded generator to provide for a larger storage facility. Factors to be considered shall include, but not limited, to geographic location of the PS and the primary fuel sources.

(3) Storage facilities stipulated in clauses (1) and (2) above shall be kept at a minimum level of 24hr continuous operation of all commercially available units at the *PS* or at any agreed levels as contained in the operating agreement, unless being used by the *SO* during the dispatch. The *generator* or *embedded generator* and *SO* shall agree on the reasonable fuel replenishing period taking into account the anticipated short term power system security requirement as well as fuel transport logistics.

18.3 Hydro power stations

(1) Hydro management at a hydro *PS* shall be as agreed with the *SO* in the operating agreement, taking into account any other applicable legal and regulatory requirements.