LESOTHO ELECTRICITYAND WATER AUTHORITY

LESOTHO GRID CODE

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LESOTHO GRID CODE

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PREAMBLE

Transmission System Operator (TSO) is responsible for the reliable and secure transmission of electrical energy through:

i. Management and operation of the Lesotho's Transmission and Sub-transmission System Grid
ii. Planning and development of the power transmission infrastructure
iii. Local and regional trade facilitation (TSO is the central buyer of power)
iv. System planning and coordination of regional interconnections through SAPP.

This maintains the placement of TSO as the key transmitter of bulk power between generators and bulk customers of electrical energy through operating and maintaining the interconnected Transmission System (the Grid). TSO's responsibilities can be expanded into the following functions: -

i. Coordinate the activities of all entities especially the operation and development of the Grid and ensure fair access to all entitiesto the Grid.

ii. Manage and control the Grid to ensure adequacy of supply.

iii. On-line (real-time) monitoring and control of the interconnected power System.

iv.Deliver power that conforms to specified quality characteristics to Distribution Systems and Transmission customers at designated Connection Points

v. Carry out statutory functions under all Acts, Rules, Laws and Regulations of the Government of Lesotho.

vi. Maintain and implement the Grid Code as approved by LEWA.

vii. Responsibilities for administering Power Supply and Power Purchase agreements.

viii. Promoting power wheeling, pooling and banking

PURPOSE OF GRID CODE

The Grid Code is a document approved by the Lesotho Electricity and Water Authority formulated in order to ensure efficient coordinated operation and maintenance of the electricity Grid. It shall be a

document agreed upon and to be complied with by TSO, DSO and Users. The Grid Code is a dynamic document that is revised periodically as per the procedures laid down, taking into account the reasonable interests and views as expressed by the stake holding entities in the light of the experience gained in the actual implementation of the Code.

OBJECTIVE OF THE GRID CODE

The objective of the Grid code is to promote sound planning, operational and connection standards in a bid to provide for reliable, secure,economic and coordinated operation of the TSO Grid. This will be achieved through the following:-

i. Specification of minimum operational standards
ii. Specification of minimum technical requirements
iii. Specification of information requirements and procedures
iv. Governing the boundaries between TSO and Users
v. Establishing minimum requirements for new entrants
vi. Streamlining responsibilities and obligations for TSO and Users

DEFINITIONS

Amended Connection Agreement - An agreement between a User and TSO(or the Distributor),which specifies the terms and conditions pertaining to the renovation or modification of the User System or Equipment at an existing Connection Point in of the Grid(or the Distribution System).

Active Power - The time average of the instantaneous power over one period of the electrical wave, measured in Watts (W) or multiples thereof. For AC circuits or systems, it is the product of the root-mean-square (RMS) or effective value of the voltage and RMS value of the in-phase component of the current. In a three-phase system, it is the sum of active power of the individual phases.

Ancillary Services - Support services such as Frequency, Regulating and Contingency Reserves, Reactive Power support, Regulation, Load Following, and Black Start capability which are necessary to support the transmission capacity and Energy that are essential in maintaining Power Quality, the Reliability and Security of the Grid. Regulation responds to rapid load fluctuations (on the order of a minute or less), and Load Following responds to slower load changes (on the order of five to thirty minutes).

Apparent Power - The product of the root-mean-square (RMS) or effective value of the current and the root-mean-square value of the voltage. For AC circuits or systems, it is the square root of the sum of the squares of the Active Power and Reactive Power, measured in volt-ampere (VA) or multiples thereof.

Automatic Generation Control (AGC) - The regulation of the power output of Generating Units in response to a change in system Frequency, tie-line loading, or the relation of these to each other, so as to maintain the System Frequency or the established interchange with other areas within the predetermined limits or both.

Automatic Load Shedding - The process of automatically and deliberately removing pre-selected Loads from a power System in response to an abnormal condition in order to maintain the integrity of the System.

Automatic Re- closing - A process used to interrupt power in the event of a fault or short circuit, and then re-instatepower or re-close the circuit after a fixed interval of time, with the objective of maintaining continuity of service to the greatest possible extent, without damaging equipment or creating unsafe conditions in the system.

Automatic Voltage Regulator (AVR) - An electrical regulator designed to automatically maintain a constant voltage level continuously.

Availability - The long-term average fraction of time that a Component or System is in service and satisfactorily performing its intended function.

Back-Up Protection - *protection* intended to operate when a *power system fault* is not cleared or an *abnormal condition* is not detected in the required time because of failure or inability of main protection to operate or failure of the appropriate circuit-breaker(s) to trip

Balanced Three-Phase Voltages - Three sinusoidal voltages with equal frequency and magnitude and displaced from each other in phase by an angle of 120 degrees.

Black Start - The process of recovery from Total System Blackout using a Generating Unit with the capability to start and synchronize with the System without an external power supply.

Capability and Availability Declaration - data submitted by the Generator for its Scheduled Generating Unit, which is used by TSO in preparing the day-ahead Generation Schedule. It includes declaration of capability and availability, Generation Scheduling and Dispatch Parameters.

Circuit Breaker - A mechanical switching device, which is capable of making, carrying, and breaking current under normal circuit conditions and also capable of making, carrying for a specified time, and breaking current under specified abnormal circuit conditions, such as a short circuit.

Committed Project Planning Data – data relating to a proposed User Development at the time the User commits to a Connection Agreement or an Amended Connection Agreement

Competent Person - A person who has sufficient technical knowledge and expertise to safely carry out specific tasks.

Completion Date - The date, specified in the Connection Agreement or Amended Connection Agreement, when the User Development is scheduled to be completed and be ready for connection to the Grid.

Component - A piece of Equipment, a line or circuit, a section of line or circuit, or a group of items, which is viewed as a unit for a specific purpose.

Connected Project Planning Data - The data, which replaces the estimated values that were assumed for planning purposes, with validated actual values.

Connection Agreement - An agreement between a User and TSO (or the Distributor), which specifies the terms and conditions pertaining to the connection of the User System or Equipment to a new Connection Point in the Grid (or the Distribution System).

Connection Conditions - The technical conditions to be complied with by aUserhaving a connection to the Transmission System.

Connection Point - The point of connection of the User System or Equipment to the Grid (for Users of the Grid) or to the Distribution System (for Users of the Distribution System).

Connection Point Drawings - The drawings prepared for each Connection Point , which indicate the equipment layout , common protection and control , and auxiliaries at the Connection Point.

Constrained Generation Schedule - The Generation Schedule prepared by TSO after considering operational constraints, including the Grid constraints, changes in Generating Unit Declared Data and parameters, and changes in forecasted data.

Contingency Planning – A Planning Criteria that a system should meet under emergency conditions.

Contingency Reserve Generating - Capacity that is intended to take care of the loss of the largest Synchronized Generating Unit or the power import from a single Grid interconnection, whichever is larger.

Control Centre - A facility used for monitoring and controlling the operation of the Grid, Distribution System, or a User System.

Controller - A senior authorised person appointed in writing by TSO, to control power in the Grid, and whose duties are to maintain safety at all times to personnel, plant and equipment.

Customer - Any person/entity supplied with electricity under a contract with TSO, a Distributor or Supplier.

Cyber Security – Cyber Security is the protection of confidentiality, integrity, and availability of the electronic communication system, data, and the critical information infrastructure.

Declared Available Capacity - the capacity of a power station in megawatts notified by a Generation Company in a Power Purchase Agreement.

Demand - The Active Power and/or Reactive Power at a given instant or averaged over a specified interval of time, that is actually delivered or is expected to be delivered by an electrical Equipment or supply System. It is expressed in Watts (W) and/or VARs and multiples thereof.

Demand Control - The reduction in Demand for the control of the Frequency when the Grid is in an Emergency State. This includes Automatic Load Shedding, Manual Load Shedding, demand reduction upon instruction by TSO, demand disconnection initiated by Users and Voluntary Load Curtailment.

Demand Forecast - The projected Demand and Active Energy related to a Connection Point in the Grid.

Dependable Capacity - The load-carrying ability of a station or system under adverse conditions for a specified period of time.

Derogation of the Grid - A condition resulting from a User Development or a Grid expansion project that has a material effect on the Grid or the Systems of other Users and which can be verified through Grid Impact Studies.

Detailed Planning Data - Additional data, which the Grid Owner requires for conducting a more accurate Grid planning study.

Disconnection - The opening of an electrical circuit to isolate an electrical System or Equipment from a power source.

Dispatch - The process of apportioning the total Demand of the Grid through the issuance of Dispatch Instructions to the Scheduled Generating Units and the Generating Units providing Ancillary Services in order to achieve the operational requirements of balancing Demand with generation that will ensure the Security

of the Grid.

Dispatch Instruction - An instruction issued by TSO Controller to the Generators with Scheduled Generating Units and the Generators whose Generating Units will provide Ancillary Services to implement the final Generation Schedule in real time.

Distribution Code - The set of rules, requirements, procedures, and standards governing DSO and Users of Distribution System in the operation, maintenance and development of the Distribution System.

Distribution - The conveyance of electrical power through a Distribution System.

Distribution System - The system of electrical lines and electrical equipment at voltage levels of 33 kV or lower.

Dynamic Instability - A condition that occurs when small undamped oscillations begin without any apparent cause because the Grid is operating too close to an unstable condition.

Earthing System - an arrangement of connections and devices necessary to earth equipment or a system separately or jointly

Earth Fault Factor - The ratio of the highest RMS phase-to-ground power Frequency voltage on a sound phase, at a selected location, during a fault to ground affecting one or more phases, to the RMS phase-to-gr ound power Frequency voltage that would be obtained at the selected location with the fault removed.

Earthing Mats- metal mats that are installed underground to form a very good ground (usually for extremely good lightning protection).

Electrical Diagram - A schematic representation, using standard electrical symbols, which shows the connection of Equipment or Power System components to each other or to external circuits.

Electricity Supply System - The combination of the Transmission System, Distribution system and power stations.

Embedded Generating Plant - A Generating Plant that is connected to a Distribution System or the System of any User and has no direct connection to the Grid.

Embedded Generating Unit – A Generating Unit that is connected within a Distribution System

Embedded Generator- A person or entity that generates electricity using an Embedded Generating Plant.

End-User - A person or entity that requires the supply of electricity for its own use.

Equipment - All apparatus, machines, conductors, etc. used as part of , or in connection with, an electrical installation.

Equipment Earthing - The connecting to earth of the non-current carrying metal parts. These include the motor body, switchgear structure, transformer core and tank, sheaths of cables and body of all portable equipment.

Equipment Identification - The System of numbering or nomenclature for the identification of Equipment at the Connection Points in the Grid.

Event - An unscheduled or unplanned occurrence of an abrupt change or disturbance in a power System due to fault , Equipment Outage, or adverse weather condition.

Fast Start – an available generating plant not synchronised to the system but capable of serving demand within 10 minutes of being requested by the System Operator.

Fault Clearance Time -The time interval from fault inception until the end of the arc extinction by the Circuit Breaker.

Fault Level - The expected current , expressed in kilo Amperes (kA) that will flow into a short circuit at a specified point in the Grid or System.

Fixed Asset Boundary Document - A document containing information and which defines the operational responsibilities for the Equipment at the Connection Point.

Flicker - A small change in line voltage, which causes a perceptible change in the intensity of electric lights.

Forced Outage - An Outage that results from emergency conditions directly associated with a Component , requiring that it be taken out of service immediately, either automatically or as soon as switching operations can be performed. Also, an Outage caused by human error or the improper operation of Equipment.

Frequency - The number of complete cycles of a sinusoidal current or voltage per unit time, usually measured in cycles per second or Hertz

Frequency Control - A strategy used by TSO to maintain the Frequency of the Grid

within the limit prescribed by the Grid Code by the timely use of Frequency Regulating Reserve, Contingency Reserve, and Demand Control.

Frequency Regulating Reserve - Refers to a Generating Unit that assists in Frequency Control by providing automatic Primary and/or Secondary Frequency response.

Frequency Variation - The deviation of the fundamental System Frequency from its nominal value.

Generating Plant - A facility, consisting of one or more Generating Units, where electrical Energy is produced from some other form of Energy by means of a suitable apparatus.

Generating Unit - A conversion apparatus including auxiliaries and associated Equipment, functioning as a single unit, which is used to produce electric Energy from some other form of Energy.

Generation Company - means an entity licenced by LEWA to operate a facility used in the Generation of Electricity.

Generation of Electricity - means production of electricity by a Generating Plant

Generation Schedule - means the schedule that indicates the hourly output of the Scheduled Generating Units and the list of Generating Units

Generation Scheduling - and Dispatch Parameters means the technical data pertaining to the Scheduled Generating Units which are taken into account in the preparation of the Generation Schedule.

Generation Unit - Any Apparatus that produces electrical energy. Such generating unit will include the mechanical prime mover (e.g. turbine or engine) in the case of conventional hydro or thermal plant or the equivalent principle means of converting another form of energy to electricity, in the case of unconventional generating units such as wind and solar energy.In the case of a multi-generating unit combined cycle block, a generating unit is an alternator plus its associated prime mover within the combined cycle block.

Generator's Declared Data – Basic data on generator's nameplate. That includes declared speed, current, voltage,tourgue and power.

Grid - the high voltage backbone System of interconnected transmission and subtransmission lines, substations, and related facilities for the purpose of conveyance of bulk power.

Grid Code - a set of rules, requirements, procedures, and standards to ensure the safe, reliable, secured and efficient operation, maintenance, and development of the Grid.

Grid Contingencies - abnormal operating conditions brought about by tripping of generatingunits, transmission lines, transformers or abrupt load changes or by a combination of the above leading to abnormal voltage and/ or frequency excursions and/or overloading of network equipment.

Grid Disturbance - a situation where disintegration and collapse of Grid, either in part or in full take place in an unplanned and abrupt manner, affecting the power supply in a large area.

Grid Impact Studies - a set of technical studies which are used to assess the possible effects of a proposed expansion, reinforcement , or modification of the Grid or a User Development and to evaluate Significant Incidents.

Grid Owner - a party that owns the Grid and is responsible for maintaining adequate Grid capacity in accordance with the provisions of the Grid Code.

Grid User - a person and/or entity connected directly to the TSO Grid, who shall comply with the provision of this Grid Code

Grounding - a conducting connection by which an electrical circuit or Equipment is connected to earth or to some conducting body of relatively large extent that serves as ground.

Harmonics - sinusoidal voltages and currents having frequencies that are integral multiples of the fundamental frequency

High Voltage (HV) - a nominal voltage levels equal to 33kVand above.

Horn Gaps - projecting conductors used to protect insulators on high voltage electric power transmission systems from damage during flashover.

IEC Standard - an international standard for electro-technical Equipment approved and published by the International Electrotechnical Commission (IEC).

Independent Power Producer (IPP) - a private Generation Company which owns facilities to generate electric power for sale to TSO and Users .

Integrating Pulse Recorder – a device which saves, in a suitable format, the data supplied by the measurement units and any calculation devices.

Interconnector - an electrical line and electrical equipment used for the transmission of electricity between the Lesotho Transmission System and the Transmission System of another country.

Interconnected Transmission System - the Grid plus the international interconnectors.

Interruption - the loss of service to a Customer or a group of Customers

Interruption Duration - a period from the initiation of an Interruption up to the time when electricity is restored.

Island Grid - a Generating Plant or a group of Generating Plants and its associated load, which is isolated from the rest of the Grid but is capable of generating and maintaining a stable supply of electricity to the Customers within the isolated area.

Isolation - the electrical separation of a part or Component from the rest of the electrical System to ensure safety when that part or Component is to be maintained or when electrical service is not required.

Limitation of Access - safety documentation to facilitate work in generation, switching or substation plant; defining limits of the area within which work is to be performed.

Load Factor - the ratio of the total Energy delivered during a given period to the product of the maximum Demand and the number of hours during the same period.

Load Reduction - a condition in which a Scheduled Generating Unit has reduced electrical power sent out to the System to which it is synchronized or ability to reduce customer demand by load curtailment or load shedding.

Local Safety Instructions - a set of instructions regarding the Safety Precautions on HV Equipment to ensure the safety of personnel carrying out work or testing on the Grid or the User System.

Loss of Load Probability (LOLP) - the expected number of days in a specified period in which the daily peak Demand will exceed the available generating capacity.

Main Distribution Frame (MDF) - an interface panel for process signals

Manual Load Shedding - the process of manually and deliberately removing pre-selected Loads from a power System, in response to an abnormal condition, and in order to maintain the integrity of the System.

Master Station – a computer system which gathers data from the various sites and also acts as operator interface for the real time monitoring and control of remote devices in the Power System

Maximum Continuous Rating (MCR) - the normal rated full load MW output capacity of a generating unit , which can be sustained on a continuous basis under specified conditions.

National Control Centre (NCC) - the TSO' s control room that provides 24 hour real time power System monitoring and control for the purpose of managing the operation of the power Systemand co-ordination of generation and consumption.

Negative Sequence Unbalance Factor - the ratio of the magnitude of the negative sequence component of the voltages to the magnitude of the positive sequence component of the voltages, expressed in percent.

Power Swing - variation in power which occurs when the voltages of generators at different points of a power system slip relative to each other.

Operator - An actual or legal person or a legal independent organization unit or an energy supply company that performs the task of transmitting or distributing electricity and is responsible of operation, maintenance or if necessary , the expansion of the Grid.

Outage - a state of a Component when it is not available to perform its intended function due to some event directly associated with that Component. An Outage may or may not cause an Interruption of service to Customers.

Outage Duration - a period from the initiation of the Outage until the affected Component or its replacement becomes available to perform its intended function.

Overvoltage - an RMS voltage variation at least 10 percent greater than the nominal voltage for a period of time greater than 3 seconds.

Planned Outage - an outage of power station equipment or transmission facility that has been planned and agreed on in advance

Peak Period - a period in a day when electrical demand is at its highest .

Project Planning Data - data pertaining to a User Development once the offer for a Connection Agreement or an Amended Connection Agreement is accepted.

Permit to Work (PTW) - safety documentation issued to facilitate work on dead (de-energised) and isolated equipment.

Point of Isolation - a point on the Grid or the User System at which Isolation can be established for safety purposes.

Power Development Plan - A tool used for planning the development of new power generation plants to meet the forecasted demand for electrical energy

Power Factor - a ratio of Active Power to Apparent Power.

Power Line Carrier (PLC) - a communication Equipment used for transmitting data signals through the use of power transmission lines.

Power Purchase Agreement (PPA) - a commercial agreement between a Generation Company and TSOin which TSOagrees to purchase the electrical output of a Generating Plant and the GeneratorCompany agrees to provide services from this plant.

Power Supply Agreement - a commercial agreement between TSO and other Grid Usersfor the supply of electrical power.

Power Station - a Generating Plant.

Power System - plant and Equipment on the generation, transmission and distribution networks.

Preliminary Project Planning Data - data relating to a proposed User Development at the time the User applies for a Connection Agreement or an Amended Connection Agreement.

Reactive Power - the component of electrical power representing the alternating exchange of stored Energy (inductive or capacitive) between sources and loads or between two systems, measured in VAr or multiples thereof.It is the product of the RMS value of the voltage and the RMS value of the quadrature component of the alternating current. In a three-phase system, it is the sum of the Reactive Power of the individual phases.

Registered Equipment Data - those items of Standard planning data and detailed planning datathat upon connection become fixed (subject to any subsequent changes)

Reliability - the probability that a System or Component will perform a required task or mission for a specified time in a specified environment . It is the ability of a Power System to continuously provide service to its Customers.

Remote Terminal Unit(RTU) - a tele-control equipment installed at a remote location to gather process information and controls the process as directed by a

central system.

Resistance Earthing - the connection of the neutral point to earth through a resistor.

Root Mean Square (RMS Voltage or RMS Current) – an AC value that produces the same heating effect in a resistor, as would a DC value of the same magnitude.

Safety Precautions - the Isolation and Grounding ofEquipment when work or testing is to be done on the Grid or User System.

Safety Rules - the rules that seek to safeguard personnel working on the Grid (or User System) from the hazards arising from the Equipment or the Grid (or User System).

Sanction for Test - a safety documentation to facilitate testing of the high voltage plant and Equipment

Scheduled Capacity – the estimated hourly generation capacity of each plant submitted to TSO by a Generation Company

Senior Authorised Person (SAP) - a Competent Person appointed in writing by TSO to carry out work and all forms of switching on the TSO Grid.

Short- term Flicker Severity Index (P_{st}) - a measure of visual severity of flicker derived from a time series output of a flicker meter over a ten-minute period

Shut Down - the condition of a Generating Unit where it is at rest or on barring gear isolated from Grid or transmission facility, which is at rest or isolated from Grid.

Single Outage Contingency - an Event caused by the failure of one Component of the Grid or a single Generating Unit.

Site - a substation or switchyard in the Grid or the User System where the Connection Point is situated.

Spinning Reserve - unused generating capacity, which is synchronised to the Power System and is ready to instantaneously provide increased generation within 10 minutes of a dispatch instruction from TSO in response to Frequency drop.

Southern Africa Power Pool (SAPP) - a regional power network in Southern Africa created with the primary aim of providing reliable and economical electricity supply to the customers of each of the SAPP members, consistent with the reasonable utilisation of natural resources and the effect on the environment through regional interconnection and harmonisation of operational procedures.

Standard Planning Data – The general data required by the TSO under the PC. It is

generally also the data that the TSO requires from a new User in applications for connection and use of System Agreements.

Substation Control System (SCS) - a combination of transducers,communication links and data processing systems which provides information to the substation on the operational state of the substation equipment.

Supervisory Control and Data Acquisition (SCADA) - a combination of transducers, RTU, communication links and data processing systems which provides information to the NCCand/or SCS on the operational state of the power system.

Supplier - a person or entity authorized by the LEWA to sell, broker, market, or aggregate electricity to the End-users.

Switching Logs – logs listing all time sequenced switching events in TSO's and Users' substations and plants

Synchronised - a state when connected Generating Units and/or interconnected AC Systems operate at the same frequency and where the phase angle displacements between their voltages vary about a stable operating point.

System - the Transmission Grid or Distribution System or a User System. Also a group of Components connected or associated in a fixed configuration to perform a specified function.

System Development Plan - A tool used for planning the development of the transmission grid, prepared annually by TSO, on the basis of: the trend in energy requirements and the predicted demand for electrical energy, which will have to be met; the need for increasing the power in the grid; and the applications for connecting new power generation plants to the grid.

System Earthing - the intentional connection of neutral point to ground so that the neutral point is earthed, in order that phase to ground voltages under Earth Fault conditions do not rise to high value.

System Loss - the Energy injected into the Grid by Generating Plants, plus (or minus) the Energy transported through Grid interconnections minus the total Energy delivered to Distributors and End-Users.

System Protection Dependability Index - The probability of not failing to operate under given conditions for a given time interval [IEC 50-448]

System Security - a continuous operation of a Power System in the normal state, ensuring safe and adequate supply of power to End-Users, even when some parts or Components of the System are on Outage.

System Test - set of tests which involve simulating normal conditions or the controlled

application of unusual or extreme conditions that may have an impact on the Grid or the User System.

System Test Coordinator - a person who is appointed as the chairman of the System Test Group.

System Test Group - a group established for the purpose of coordinating the System Test to be carried out on the Grid or the User System.

System Test Procedure - a procedure that specifies the switching sequence and proposed timing of the switching sequence, including other activities deemed necessary and appropriate by the System Test Group in carrying out the System Test.

System Test Proponent the TSO or the User who plans to undertake a System Test and who submits a System Test Request to TSO.

System Test Program - a program prepared by the System Test Group, which contains the plan for carrying out the System Test, the System Test Procedure, including the manner in which the System Test is to be monitored, the allocation of costs among the affected Users, and other matters that the System Test Group had deemed appropriate and necessary.

System Test Report - a report prepared by the Test Proponent at the conclusion of a System Test for submission to TSO (if it is not the System Test Proponent), the affected Users, and the members of the System Test Group.

System Test Request - a request submitted by the System Test Proponent to TSO indicating the purpose, nature, and procedures for carrying out the proposed System Test.

Synchronised - a condition where an incoming Generating Unit or System is connected to another System so that the voltage, frequencies and phase relationships of that generating unit or System, as the case may be, and the System to which it is connected are identical.

Target Clearance Time - the time between relay pick up and the time the fault is cleared.

Technical Loss - a component of System Loss that is inherent in the physical delivery of electrical Energy. It includes conductor loss, transformer core loss, and technical errors in meters.

Teleprotection - the use of telecommunication channels to operate protection relays through command signals, so as to enable the relays to selectively isolate faults within the shortest possible time and independent of fault location and system conditions.

Teleprotection Security - the ability to prevent interference and or noise from generating a trip command at the receiving end when such a command has not been transmitted.

Teleprotection Dependability - the ability to execute a valid command at the receiving end in the presence of interference and/or noise when such command has been transmitted.

Teleprotection Transmission Time - the time elapsed between the moment of change of state at the trnsmitter command input and the moment of change of state at the receiver command output.

Test and Commissioning - putting into service a System or Equipment that has passed all required tests to show that the System or Equipment was erected and connected in the proper manner and can be expected to work satisfactorily.

Total Demand Distortion (TDD) - the ratio of the root-mean-square value of the harmonic content to the root-mean-square value of the rated or maximum demand fundamental quantity, expressed in percent.

Total Harmonic Distortion (THD) - the ratio of the root-mean-square value of the harmonic content to the root-mean-square value of the fundamental quantity, expressed in percent.

Total System Blackout - The condition when all generation in the Grid has ceased, the entire Power System has Shutdown.

Transformer - an electrical device or Equipment that converts voltage and current from one level to another.

Transient - a very brief excursion from nominal voltage with durations of a microsecond (millionths of a second) to several hundred microseconds. Transients are classified as impulsive or oscillatory.

Transient Instability - a condition that occurs when undamped oscillations between parts of the Grid result in Grid separation. Such Grid disturbances may occur after a fault and the loss of Generating Units and/or transmission lines.

Transient Voltages - high-frequency Overvoltages caused by lightning, switching of capacitor banks or cables, load chopping, arcing ground faults, ferroresonance, and other related phenomena.

Transmission Development Plan - System planning practices and considerations that the TSO follows.

Transmission System (TS) - lines and substation equipment where the nominal voltage is at or above 33 kV.

Transmission System Operator (TSO) - an entity licensed to operate and maintain a TS.

Unconstrained Generation Schedule - the Generation Schedule without considering any operational constraints such as the Grid constraints, changes in Generating Unit Declared Data and parameters, and changes in forecasted data.

Underfrequency Relay (UFR) – an electrical relay that operates when the System Frequency decreases to a preset value.

Under Voltage - an RMS voltage variation at least 10 percent below the normal (nominal) voltage for a period of time greater than 3 seconds.

Voltage Sag - a decrease to 90% in the RMS voltage at the power frequency for durations of 20 miliseconds to 3 seconds.

Voltage Swell – an increase to 110% in the RMS value of voltage at the power frequency, for 20 miliseconds to 3 seconds..

User - a person or entity that uses the Grid or Distribution System and related facilities. Also, a person or entity to whom the Grid Code or Distribution Code applies.

User System - a System owned or operated by a User of the Grid or Distribution System.

Visitors Live Line Enclosure Permit (VLLEP) - a safety document signed by visitors acknowledging the dangers of entering a live line enclosure and indemnifying TSO against injury, whilst they are in the live enclosure.

Voltage - an electromotive force or electric potential difference between two points, which causes the flow of electric current in an electric circuit.

Voltage Control - the strategy used by TSO, Distributors, or User to maintain the voltage of the Grid, Distribution System, or the User System within the limits prescribed by the Grid Code or the Distribution Code.

Voltage Fluctuation - the systematic variation of the voltage envelope or random amplitude changes where the RMS values of voltage is between 90% and 100%

Voltage Instability - a condition that results in Grid voltages that is below the level where voltage control Equipment can return them to the normal level.

Voltage Variation - the deviation of the root-mean-square (RMS) value of the voltage from its nominal value, expressed in percent.

Wheeling Charge- the tariff paid for the conveyance of electric Power and Energy through the Grid.

SECTION 1

GOVERNANCE CODE

1 Introduction

Under the terms of the Lesotho Electricity Authority Act, the Transmission Licensee (TSO) is required to implement and ensure compliance to the Grid Code and to periodically review the same and its implementation. Such review shall be subject to approval by LEWA.

1.1 Objective

The objective of this Code is to define the management and governance of the Grid Code, submitting and pursuing of any proposed changes to the Grid Code and the responsibility of all Users to effect that change.

1.2 Responsibilities

TSO will be responsible for supporting and servicing LEWA in managing and enforcing the Grid Code, per its obligations under the License. In this regard, TSO shall help LEWA establish the Grid Code Review Panel and service the requirements of such a Panel.

1.4 Grid Code Review Panel

The Panel shall be chaired by TSO and shall consist of the following members:

Chairman from LEWA
TWo members from the TSO
One member from a Distribution System Operator, if any
One member from main generators connected to the Grid
One member from large users directly connected to the Grid
One member from Embedded Generators
One member from Consulting Companies

Members of the Grid Code Review Panel shall possess relevant technical skills and shall be subject to approval by LEWA. All members shall have a designated backup replacement to serve in the review process in case of unforeseen circumstances. LEWA shall be immediately informed of changes in the composition of the Grid Code Review Panel and shall approve such changes.

For continuity purposes, membership of individuals from above entities shall be for five years and any changes of member representation by entities shall be communicated in writing to LEWA within thirty (30) days.

TSO shall provide the secretarial functions of the Grid Code Review Panel. In this regard, TSO shall designate an appropriate official to coordinate the activities of the Grid Code Review Panel to ensure compliance to the Grid Code, its revisions and amendments. Lesotho Electricity and Water Authority (LEWA) shall approve the Grid Code and all the amendments and ensure compliance.

1.5 Standing Committees to deal with specific issues

The Grid Code Review Panel can at its discretion form standing committees to deliberate and recommend on specific issues.

The Grid Code Review Panel, at its discretion, shall invite to its meetings, Chairmen of each of the Standing Committees concerned with particular items on their Agendas. The Chairman of a Standing Committee may delegate a representative from the Standing Committee to take part in the discussion.

The Panel, at its discretion, may invite representatives from Consultants and/or any other Organization such as Government Departments, Local Authorities, Telecommunications, Financing Institutions or academic/ technical institutions, to attend the Panel meeting depending on the Agenda. Such invited members can express or offer advice on the matter under consideration but shall act as observers in the final determination.

1.6 Grid Code Review Panel Rules

The rules to be followed by the Panel in conducting its business shall be formulated by the Panel itself and shall be approved by LEWA. The Panel will meet at least once in three months in the first year of its establishment. Thereafter meetings shall be held when there are issues for discussion.

No revision or modification of the Grid Code shall be made without knowledge of the Grid Code Review Panel and LEWA approval.

In an unusual situation where normal day-to-day operation is not possible without TSO violating some clauses of the Grid Code, a suspension of compliance and provisional revision may be implemented before approval of LEWA is received, but only after discussion by the Grid Code Review Panel through a Meeting convened on emergency basis. LEWA shall promptly be informed about the suspension of compliance and provisional revision in writing and determine whether to approve, amend, or disapprove the suspension of compliance and the revisions within

fourteen (14) days from the date of notification by the Grid Code Review Panel.

LEWA may issue directions requiring the Grid Code Review Panel and the TSO to revise the Grid Code in such a manner as may be specified in those directions, and the Grid Code Review Panel and the TSO shall promptly comply with any such directions

1.7 Functions of the Grid Code Review Panel

The functions of the panel are as follows:

a) To keep the Grid Code and its implementation under continuous scrutiny and review.
b) To analyse any major Grid disturbances within fourteen calendar days after the occurrence and evolve any consequent revision to the Grid Code.
c) To consider all requests for amendment to the Grid Code which are proposed by the Users.
d) To recommend to LEWA, changes to the Grid Code together with the reasons for the changes and any objections, if applicable.
e) To issue guidance on the interpretations and implementation of the Grid Code
f) To examine problems raised by Users pertaining to the implementation of the Grid Code.

TSO may hold sub-meetings with a User to discuss individual requirements and with a group of Users to prepare proposals for the Panel meeting.

1.8 Grid Code Review and Revisions Procedures

The Member Secretary shall present all proposed revisions to the Grid Code to the Review Panel for its consideration.

TSO shall send a report to LEWA at the conclusion of each review meeting of the Panel containing the following:

a) Proposed revisions to the Grid Code.
b) All written representations or objections from Users raised during the review.
c) The outcome of such a review.

All revisions to the Grid Code shall require approval of LEWA. TSO shall publish revisions to the Grid Code, once approved by LEWA.

Every change from the previous Version shall be clearly marked in the margin. In addition, a revision sheet shall be placed at the front of the Revised Version noting the number of every changed sub-section, together with a brief statement of change.

TSO shall keep an up-to-date list of the recipients and locations of all serviced copies of the Grid Code.

1.9.Disputes

The Grid Code Review Panel shall handle disputes regarding interpretation of the Grid Code. If one or both Users are not satisfied with the ruling of the Panel the matter shall be referred to LEWA whose decision is final.

1.9.1. Issues not covered by the Grid Code

Any technically relevant issues not covered by the Grid Code shall be referred to the Grid Code Review Panel for further consideration for inclusion in the Grid Code. The Grid Code Review Panel's ruling on such issues shall be binding. If any party is not satisfied by the ruling of the Grid Code Review Panel, the matter shall be referred to LEWA. The decision of LEWA shall be final and binding.

1.9.2 Continuity of Functioning of Grid Users

After a dispute arises between entities, the matter shall immediately be referred to the Grid Code Review Panel which shall make provisional working arrangements that shall be implemented until a valid ruling is issued according to Section 1.9.1 above. The objective of this procedure is to ensure that no dispute shall stall the daily operations of any Grid User .

1.9.3 Unforeseen Circumstances

In situations not addressed by any clause of the Grid Code, TSO shall convene an emergency meeting with all affected Grid Users to formulate a solution and the actions to be taken in the circumstance by the Grid Users. If no agreement can be reached, TSO shall provisionally determine the action to be taken after giving consideration to the views expressed by other Users.TSO shall, as soon as possible, but not later than fourteen days, refer the matter to the Grid Code Review Panel whose decision shall prevail over the provisional determination of TSO. If a Grid User appeals to LEWA over the decision of the Panel, the decision of LEWA shall supersede the decision of the Panel.

The normal operations of any User should never be disrupted by any situation or dispute. The majority decision of the meeting of Grid Users or the considered determination of TSO shall be implemented unless and until the Grid Code Review Panel issues a different ruling; and the ruling of the Panel shall be in force unless and until a different decision is issued by LEWA (if the issue is referred to LEWA). The decision of LEWA is ultimate and shall be implemented by all Grid Users.

SECTION 2

CONNECTION CODE

2.1 Introduction

This Grid Connection Code is for the protection of the Transmission System and Users'Plant and Apparatus directly connected to the Transmission System. In order to maintain stable and secure operation of the Transmission System for the benefit of all Users, it is necessary to require certain minimum technical, design and operational criteria to be met by Users' Plant and Apparatus. The Grid Connection Requirements establish certain principles and standards relating to method of connection, technical standards, performance standards, and data requirements. In addition to the Connection Requirements, there are Connection Agreements, which are bilateralbetweenTSO and each user and which contain the details specific to each User's connection to the Transmission System Grid. Such agreements between the User and TSO shall comply with the Grid Code.

2.1.1 Purpose

The purpose of the Grid connection Code is:

a) To specify the technical, design, and operational criteria at the User's Connection Point
b) To ensure that basic rules for connection to the Grid or to a User's system are fair and non discriminatory for all Users.
c) To ensure that any new connection shall not impose any adverse effects on existing Users
d) To ensure that new connections shall not suffer adversely due to existing Users
e) To assist Users in the maintenance of acceptable reliability and quality levels through specification of minimum design and operational criteria.
f) To list and collate data required by TSO from all Users
g) To list data to be provided by TSO to each User

2.1.2 Scope of Grid Connection Requirements

The Grid connection requirements shall apply to:
a) TSO
b) DSO
c) Any generator connected or to be connected to TSO System
d) Any User connected to or intending to be connected to TSO System
e) Any other Transmission System within or outside Lesotho connected or intending to be connected to TSO system

f) Any provider of Ancillary Services to the Transmission System

2.2 Grid Technical, Design and Operational Criteria

2.2.1 Power Quality Standards

2.2.1.1 TSO shall ensure that at any Connection Point in the Grid, the power quality standards specified in Section 3 of this Grid Code are complied with.

2.2.1.2 Users seeking connection to the Grid or modification of any existing connection shall ensure that their equipment can operate reliably and safely within the limits specified in Section 3 of this Grid Code during normal and emergency conditions and can withstand the limits specified therein.

2.2.2 Frequency Variation

2.2.2.1 TSO Grid rated frequency shall be 50.0 Hz with a control range within the range of 49.5 Hz to 50.5Hz. All loads and generators connected to TSO Grid should be able to operate within this range without being affected negatively.

2.2.2.2 In emergency operating conditions the automatic load shedding scheme shall be undertaken according to rules specified in Section 4 of this Grid Code.

2.2.3 Voltage Variations

The Long Duration Voltage Variations at any Connection Point during normal and emergency conditions shall be within the limits specified in Section 3.3.3 of this Grid Code.

2.2.4 Harmonics

The Total Harmonic Distortion of the voltage and the Total Demand Distortion of the current, at any Connection Point, shall not exceed the limits prescribed in Section 3.3.2 of this Grid Code.

2.2.5 Voltage Unbalance

The maximum Zero and Negative Sequence Unbalance Factors at any Connection Point in the Grid shall not exceed the limits specified in Section 3.3.4 of this Grid Code, during normal and emergency operating conditions.

2.2.6 Voltage Fluctuation and Flicker Severity

The Voltage Fluctuation at any Connection Point with a fluctuating Demand shall not exceed the limits specified in Section 3.3.5 of this Grid Code, during normal and emergency operation conditions.

2.2.7 Transient Voltage Variations

The Grid and the User System shall be designed and operated to include devices that will mitigate the effects of transient over voltages on the Grid and the User System. TSO and the User shall take into account the effect of electrical transients when specifying the insulation of their electrical Equipment.

2.2.8 Grounding Requirements

The Grid shall be effectively grounded with an Earth Fault Factor of less than 1.4 for all voltage levels connected to the Grid.

2.2.9 Equipment Standards

All Equipment at the Connection Point shall comply with the requirements of the IEC Standards or their equivalent Lesotho national standards.

2.3 Requirements for Grid Connection or Modification

Any user seeking to establish new or modified arrangements for connection to and/or use of the Transmission System shall follow the procedures laid out below.

2.3.1 Connection Agreement

2.3.1.1 Any User seeking use of the Transmission System must submit an application for connection to TSO using the application forms available from TSO.

2.3.1.2 The connection agreement shall include the provisions for the submission of information, reports, safety rules, test and commissioning programs, electrical diagrams, statement of readiness to connect and any other requirements that may from time to time be specified by TSO.

2.3.2 Amended Connection Agreement

2.3.2.1 Any User seeking a modification of any existing connection to the Grid shall secure the required amended connection agreement with TSO prior to the actual modification of the existing connection to the Grid.

2.3.2.2 The amended connection agreement shall include provisions for the submission of additional information and reports required by TSO

2.3.3 Grid Impact Studies

2.3.3.1TSO shall develop and maintain a set of required technical impact studies for evaluating the impact on the Grid of any proposed connection or modification to an existing connection. These impact studies shall be completed within thirty(30) calendar days of application.

2.3.3.2 TSO shall specify which of the planning studies described in Section 4 of this Grid Code will be carried out to evaluate the impact to the Grid of the proposed User's Development.

2.3.3.3 The User shall indicate whether it wishes TSO to undertake additional technical studies. The User shall shoulder the cost of the additional technical studies.

2.3.3.4 Any User applying for connection or a modification of an existing connection to the Grid shall take all necessary measures to ensure that the proposed User Development will not result in the derogations of the Grid. TSO may disapprove an application for connection or a modification to an existing connection, if the Grid Impact Studies show that the proposed User Development will result in the Derogation of the Grid.

2.3.3.5 To enable TSO to carry out the necessary detailed Grid Impact Studies, the User is required to provide all the necessary Detailed Planning Data, as prescribed by TSO from time to time, prior to any connection.

2.3.3.6 TSO shall maintain an up to date fault level database that should be made available on request by Grid Users. TSO shall inform the Grid User, if fault levels at a Connection Point are likely to impact adversely on the User's Equipment connected to the Grid. TSO shall also provide information on mitigation measures (e.g. a special protection system) as needed.

2.3.4 Procedures for Application for Connection or Modification

2.3.4.1 TSO shall establish the procedures for the processing of applications for connection or modification of an existing connection to the Grid.

2.3.4.2 The User shall submit to TSO the completed application form for connection or modification of an existing connection to the Grid. The application form shall include the following information:

(a) A description of the proposed connection or modification to an existing connection, which shall comprise the User Development at the Connection Point;
(b) The relevant Standard Planning Data listed in Section 4 of this Grid Code and any other relevant data as prescribed by TSO from time to time.
(c) The Completion Date of the proposed User Development.

2.3.4.3 The User shall submit the planning data in three (3) stages, according to their degree of commitment and data requirement as follows:
a) Preliminary Project Planning Data;
b) Committed Project Planning Data; and
c) Connected Project Planning Data.

2.3.5 Processing of Application

2.3.5.1 TSO shall process and provide feedback on the application for connection or modification to an existing connection within thirty (30) calendar days from the submission of the completed application form.

2.3.5.3 If the application of the User is acceptable, TSO and the User shall sign a Connection Agreement or an Amended Connection Agreement, as the case may be.

2.3.5.4 If the application of the User is not acceptable, TSO shall notify the User why its application is not acceptable. TSO shall include in its notification a proposal on how the User's application will be acceptable to TSO.

2.3.5.5 The User shall accept the proposal of TSO within 90 (ninety) calendar days from the date of notification by TSO after which the proposal automatically lapses.

2.3.5.6 The acceptance by the User of TSO's proposal shall lead to the signing of a Connection Agreement or an Amended Connection Agreement.

2.3.5.7 If TSO and the User cannot reach an agreement on the proposed connection or modification to an existing connection, TSO or the User may bring the matter before the LEWA for resolution.

2.3.6 Submittals Prior to the Commissioning Date

2.3.6.1 The following shall be submitted by the User to TSO prior to the commissioning date, pursuant to the terms and conditions and schedules specified in the Connection Agreement:

a) Specifications of major Equipment not included in the Standard Planning Data and Detailed Planning Data;
b) Details of the protection arrangements and settings referred to in Section 7 of this Grid Code for Generating Units, Distributors and other Grid Users;
c) Information to enable TSO to prepare the Fixed Asset Boundary Document as provided for in Section 2.7.
d) Electrical Diagrams of the User's Equipment at the Connection Point as described in Section 2.7.
e) Information that will enable TSO to prepare the Connection Point Drawings, referred to in Section 2.8.
f) Copies of all Safety Rules and Local Safety Instructions applicable to the User's Equipment and a list Safety Coordinators.
g) A list of the names and telephone numbers of authorized representatives, including the confirmation that they are fully authorized to make binding decisions on behalf of the User.
h) Proposed Maintenance Program; and
i) Test and Commissioning procedures at the Connection Point and the User Development.

2.3.7 Commissioning of Equipment and Physical Connection to the Grid

2.3.7.1 Upon completion of the User Development, including work at the Connection Point , the Equipment at the Connection Point and the User Development shall be subjected to the Test and Commissioning procedures specified in Section 7 of this Grid Code.

2.3.7.2 The User shall then submit to TSO a statement of readiness to connect, which shall include the Test and Commissioning reports.

2.3.7.3 Upon acceptance of the User ' s statement of readiness to connect , TSO shall, within fifteen (15) working days, issue a certificate of approval to connect.

2.3.7.4 The physical connection to the Grid shall be made only after the certificate of approval to connect has been issued by TSO to the User.

2.4 Requirements for Large Generators

2.4.1 Requirements Relating to the Connection Point

2.4.1.1 The Generator's Equipment shall be connected to the Grid at the voltage level(s) agreed to by TSO and the Generator based on Grid Impact Studies.

2.4.1.2 The Connection Point shall be controlled by a circuit breaker that is capable of interrupting the maximum short circuit current at the

point of connection as specified by TSO.

2.4.1.3 Isolators shall be provided to adequately isolate the circuit breaker for maintenance purposes at the local point.

2.4.2 Generating Unit Power Output

2.4.2.1 The Generating Unit shall be capable of continuously supplying its Active Power output, as specified in the Generator's Declared Data, within the System Frequency range of 50.5 to 49.5 Hz as per SAPP requirements.

2.4.2.2 The Generating Unit shall be capable of supplying its Active Power and Reactive Power outputs, as specified in the Generator's Declared Data, within the voltage variations specified in Section 3.3.3 of this Grid Code during normal and emergency operating conditions.

2.4.2.3 The Generating Unit shall be capable of supplying its Active Power output, as specified in the Generator's Declared Data, within the limits of 0.93 Power Factor lagging and 0.98 Power Factor leading at the Generating Unit's terminals, in accordance with its Reactive Power Capability Curve.

2.4.3 Frequency Withstand Capability

2.4.3.1 The generating units should be capable of operating in synchronism when the System frequency momentarily rises to 51.5 Hz or falls to 48.5 Hz.

2.4.3.2 The Generator shall be responsible for protecting its Generating Units against damage for frequency excursions outside the range of 51.5 Hz and 48.5 Hz. The Generator shall provide adequate protection to disconnect the Generating Unit from the Grid, if the frequency is outside limits 51.5Hz and 48.5Hz.

2.4.4 Unbalance Loading Withstand Capability

2.4.4.1 The Generating Unit shall meet the requirements for Voltage Unbalance as specified in Section 3.3.4 of this Grid Code.

2.4.4.2 The Generating Unit shall also be required to withstand without tripping, the unbalance loading during clearance by the Backup Protection of a close-up phase-to-phase fault on the Grid or, in the case of an Embedded Generating Unit, on the User System.

2.4.5 Speed- Governing System

2.4.5.1 The Generating Unit shall be capable of contributing to Frequency Control by continuous regulation of the Active Power supplied to the Grid or to the User System in the case of an Embedded Generating Unit. The Generating Unit shall be fitted with a fast-acting speed- governing system to provide Frequency Control under normal operating conditions. All governors shall have droop settings adjustable between 3% and 6% and should be set at 5% or any such setting as given by TSO National Control Centre.

2.4.5.2 When a Generating Unit becomes isolated from the Grid, the speed - governing System shall provide Frequency Control to the resulting Island Grid. Exemptions from this requirement shall be specified in the Connection Agreement or Amended Connection Agreement.

2.4.6 Excitation Control System

2.4.6.1 The Generating Unit shall be capable of contributing to Voltage Control by continuous regulation of the Reactive Power supplied to the Grid or, in the case of Embedded Generating Unit, to the User System.

2.4.6.2 The Generating Unit shall be fitted with a continuously acting automatic excitation control System to control the terminal voltage without instability over the entire operating range of the Generating Unit.

2.4.6.3 The performance requirements for excitation control facilities, including power System stabilizers, where necessary for System operations shall be specified in the Connection Agreement or Amended Connection Agreement.

2.4.7 Black Start Capability

2.4.7.1 The Grid shall have Black Start capability at a number of strategically located Generating Plants.

2.4.7.2 The Generator shall specify in its application for a Connection Agreement or Amended Connection Agreement if its Generating Unit has a Black Start capability.

2.4.8 Fast Start Capability

The Generator shall specify in its application for a Connection Agreement or Amended Connection Agreement if its Generating Unit has a Fast Start capability.

2.4.9 Protection Arrangements

2.4.9.1 The protection of Generating Units and Equipment and their connection to the Grid shall be designed, coordinated, and tested to achieve the desired level of speed, sensitivity, dependability and selectivity in fault clearing and to

minimize the impact of faults on the Grid as specified under Section 7 of this Grid Code.

2.4.9.2 TSO and the User shall be solely responsible for the protection System of the electrical equipment and facilities on their respective sides of the Connection Point.

2.4.9.3 The site specific Fault Clearance Time shall be specified in the Connection agreement or Amended Connection Agreement. The general clearance times are for guidance purposes as specified in Section 7 of this Grid Code.

2.4.9.4 Where the Generator's Equipment is connected to the Grid and a circuit breaker is provided by the Generator (or by TSO) at the Connection Point, a circuit breaker fail protection shall also be provided by the Generator (or TSO).

2.4.9.5 The circuit breaker fail protection shall be designed to initiate the tripping of all the necessary electrically adjacent circuit breakers and to interrupt the fault current within the next 50 milliseconds, in the event that the primary protection system fails to interrupt the fault current within the prescribed Fault Clearance Time.

2.4.9.6 The Generator shall provide protection against loss of excitation on the Generating Unit.

2.4.9.7 The Generator shall provide protection against pole-slipping on the Generating Unit.

2.4.9.8 The ability of the protection scheme to initiate the successful tripping of the Circuit Breakers, as measured by the System Protection Dependability Index, shall be not less than 99 percent.

2.4.9.9 All Grid Users shall provide adequate space for accommodation of TSO's protection equipment , communication equipment and network control equipment.

2.4.10 Transformer Connection and Grounding

2.4.10.1 If the Generator's Equipment is connected to the Grid, the high-voltage side of the transformer shall be connected in Wye (Y), with the neutral available for connection to ground.

2.4.10.2 TSO shall specify the connection and grounding requirements for the LV side of the transformer, in accordance with the provisions of Section 7 of this Grid Code.

2.5 REQUIREMENTS FOR DISTRIBUTORS AND OTHER GRID USERS

2.5.1 Requirements Relating to the Connection Point

2.5.1.1 The Distributor's or other Grid User 's Equipment shall be connected to the Grid at voltage level(s) agreed to by TSO and the Distributor (or other Grid User) based on Grid Impact Studies.

2.5.1.2 The Connection Point shall be controlled by a circuit breaker that is capable of interrupting the maximum short circuit current as specified by TSO at the point of connection.

2.5.1.3 Isolators shall also be provided to adequately isolate the circuit breaker for maintenance purposes at the local point.

2.5.2 Protection Arrangements

The protection of the Distributor's or other Grid User's Equipment at the Connection Point shall be designed, coordinated, and tested to achieve the desired level of speed, sensitivity, and selectivity in fault clearing and to minimize the impact of faults on the Grid as per the guidelines in Section 7 of this Grid Code.

2.5.3 Transformer Connection and Grounding

2.5.3.1 If the Distributor's or other Grid User's Equipment are connected to the Grid, the high-voltage side of the transformer shall be connected in Wye, with the neutral available for connection to ground.

2.5.3.2 TSO shall specify the connection and grounding requirements for the low-voltage side of the transformer, in accordance with the provisions of Section 7 of the Grid Code.

2.5.4 Underfrequency Relays for Automatic Load Shedding

2.5.4.1 The Connection Agreement or Amended Connection Agreement shall specify the manner in which Demand, subject to Automatic Load Shedding, will be split into discrete MW blocks to be actuated by Underfrequency Relays.

2.5.4.2 The voltage supply to the Underfrequency Relays shall be sourced from the primary System at the supply point to ensure that the input Frequency to the Underfrequency Relay is the same as that of the primary System.

2.5.4.3 The tripping facility shall be designed and coordinated in accordance with the reliability levels specified by TSO. The overall dependability shall not be lower than 99%.

2.6 COMMUNICATION AND SCADA EQUIPMENT REQUIREMENTS

2.6.1 Communication System for Monitoring and Control

2.6.1.1 A communication System shall be established so that TSO and the Users can communicate with one another , as well as exchange data signals for monitoring and controlling the Grid during normal and emergency conditions.

2.6.1.2 TSO shall provide the complete communication Equipment required for the monitoring and control of the Connection Point and the Generating Units. A connection fee shall be charged to the user of the Grid as per the Connection Agreement for the provision of such equipment.

Communication Equipment shall conform to the interface standard and protocol specified by TSO. The Generators to be under control shall be specified in the Connection Agreement.

2.6.1.3 TSO may use a combination of digital and analogue communication media.

2.6.2 SCADA System for Monitoring and Control

2.6.2.1 Overall real time operation and monitoring of the Grid shall be supervised from the National Control Centre. The National Control Center shall be manned around the clock.

2.6.2.2 TSO shall provide a Remote Terminal Unit (RTU) for interconnection with the National Control Centre, to serve as Telecontrol Equipment for monitoring real-time information and controlling the Equipment at the Connection Point. The costs of such equipment shall be borne by customers as connection fees as per Connection Agreement.

2.6.2.3 The RTU shall be compatible with the Master Station protocol requirements and modem specifications of TSO. In the event that the Master Station is changed, TSO shall be responsible for any change needed for the RTU to match the new requirements.

2.6.2.4 TSO shall also provide, if applicable, other related Equipment such as transducers, cables, modems, etc. for interconnection with the SCADA System of the Grid. The costs of such equipment shall be borne by customers as connection fees as per Connection Agreement.

2.7 FIXED ASSET BOUNDARY DOCUMENT REQUIREMENTS

2.7.1 Fixed Asset Boundary Document

2.7.1.1 The Fixed Asset Boundary Documents for any Connection Point shall provide the information and specify the operational responsibilities of TSO and the User for the following:

a) HV Equipment;
b) LV and MV Equipment; and
c) Communications and metering equipment.

2.7.1.2 The Fixed Asset Boundary Document shall show precisely the Connection Point and shall specify the following:

a) Equipment and their ownership;
b) Safety Rules and procedures including Local Safety Instructions;
c) Operational procedures and the responsible party for operation and control;
d) Maintenance requirements and the responsible party for undertaking maintenance; and
e) Any agreement pertaining to emergency conditions.

2.7.1.3 The Fixed Asset Boundary Documents shall be available at all times for the use by the operations personnel of TSO and the User.

2.7.2 Accountable Managers

2.7.2.1 Prior to the Completion Date specified in the Connection Agreement or Amended Connection Agreement, the User shall submit to TSO a list of Accountable Managers who are duly authorized to sign the Fixed Asset Boundary Documents on behalf of the User.

2.7.2.2 Prior to the Completion Date specified in the Connection agreement or Amended Connection Agreement, TSO shall provide to the User the name of the Accountable Manager who shall sign the Fixed Asset Boundary Documents on behalf of TSO.

2.7.2.3 Any change to the list of Accountable Managers shall be communicated to the other party at least six (6) weeks before the change becomes effective. If the change was not anticipated, it must be communicated as soon as possible to the other party, with an explanation why the change had to be made.

2.7.2.4 Unless specified otherwise in the Connection Agreement or the Amended Connection Agreement, the construction, Test and Commissioning, control, operation and maintenance of Equipment, accountability shall be the

responsibility of the owner.

2.7.3 Preparation of Fixed Asset Boundary Document

2.7.3.1 TSO shall establish the procedure and forms required for the preparation of the Fixed Asset Boundary Documents.

2.7.3.2 The User shall provide the information that will enable TSO to prepare the Fixed Asset Boundary Document , in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.7.3.3 TSO shall prepare a preliminary Fixed Asset Boundary Document for the Connection Point at least two (2) weeks prior to the Commissioning date. The final Fixed Asset Boundary Document shall be produced at most two (2)weeks after the commissioning of the connection point

2.7.3.4 The Fixed Asset Boundary Document for the Equipment at the Connection Point shall include the details of the lines or cables emanating from TSO' s and the User ' s sides of the Connection Point.

2.7.3.5 The date of issue and the issue number shall be included in every page of the Fixed Asset Boundary Document.

2.7.4 Signing and Distribution of Fixed Asset Boundary Document

2.7.4.1 Prior to the signing of the Fixed Asset Boundary Document, TSO shall send a copy of the completed Fixed Asset Boundary Document to the User, for any revision or for confirmation of its accuracy.

2.7.4.2 The Accountable Managers designated by TSO and the User shall sign the Fixed Asset Boundary Document, after confirming its accuracy.

2.7.4.3 TSO shall provide two (2) copies of the Fixed Asset Boundary Document to the User, with a notice indicating the date of issue, the issue number and the implementation date of the Fixed Asset Boundary Document.

2.7.5 Modifications of an Existing Fixed Asset Boundary Document

2.7.5.1 When a User has determined that a Fixed Asset Boundary Document requires modification, it shall inform TSO at least eight (8) weeks before implementing the modification. TSO shall then prepare a revised Fixed Asset Boundary Document at least six (6) weeks before the implementation date of the modification.

2.7.5.2 When TSO has determined that a Fixed Asset Boundary Document requires modification, it shall prepare a revised Fixed Asset Boundary Document at least six (6) weeks prior to the implementation date of the

modification.

2.7.5.3 When TSO or a User has determined that a Fixed Asset Boundary Document requires modification to reflect an emergency condition, TSO or the User, as the case may be, shall immediately notify the other party. TSO and the User shall meet to discuss the required modification to the Fixed Asset Boundary Document, and shall decide whether the change is temporary or permanent in nature. Within seven (7) days after the conclusion of the meeting between TSO and the User, TSO shall provide the User a revised Fixed Asset Boundary Document.

2.7.5.4 The procedure specified in Section 2 .6 .4 of this Grid Code for signing and distribution shall be applied to the revised Fixed Asset Boundary Document. TSO' s notice shall indicate the revision(s), the new issue number and the new date of issue.

2.8 ELECTRICAL DIAGRAM REQUIREMENTS

2.8.1 Responsibilities of TSO and Users

2.8.1.1 TSO shall specify the procedure and format to be followed in the preparation of the Electrical Diagrams for any Connection Point.

2.8.1.2 The User shall prepare and submit to TSO an Electrical Diagram for all the Equipment on the User 's side of the Connection Point , in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.8.1.3 TSO shall provide the User with an Electrical Diagram for all pertinent Equipment on TSO's side of the Connection Point, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.8.1.4 If the Connection Point is at the User's Site, the User shall prepare and distribute a composite Electrical Diagram for the entire Connection Point. Otherwise, TSO shall prepare and distribute the composite Electrical Diagram for the entire Connection Point.

2.8.2 Preparation of Electrical Diagrams

2.8.2.1 The Electrical Diagrams shall provide an accurate record of the layout and circuit connections, ratings and identification of Equipment, and related apparatus and devices at the Connection Point.

2.8.2.2 If possible, all the Equipment at the Connection Point shall be shown in one Electrical Diagram. When more than one Electrical Diagram is

necessary, duplication of identical information shall be minimized. The Electrical Diagrams shall represent the physical arrangement of the quipment and their electrical connections.

2.8.2.3 The current status of the Equipment shall be indicated in the diagram. For example, a spare switch bay shall be labeled "Spare Bay."

2.8.2.4 The title block of the Electrical Diagram shall include the names of authorizing persons together with provisions for the details of revisions, dates, and signatures.

2.8.3 Changes to Electrical Diagrams

2.8.3.1 If TSO or a User decides to add new Equipment or change an existing Equipment Identification, TSO or the User, as the case may be, shall provide the other party a revised Electrical Diagram, at least one month prior to the proposed physical addition or change.

2.8.3.2 If the modification involves the replacement of existing Equipment, the revised Electrical Diagram shall be provided to the other party in accordance with the schedule specified in the Amended Connection Agreement.

2.8.3.3 The revised Electrical Diagram shall incorporate the new Equipment to be added, the existing Equipment to be replaced or the change in Equipment Identification.

2.8.4 Validity of Electrical Diagrams

2.8.4.1 The composite Electrical Diagram prepared by TSO or the User , in accordance with the provisions of Section 2.8.1 of the Grid Code, shall be the Electrical Diagram to be used for all operation and planning activities associated with the Connection Point.

2.8.4.2 If differences arise pertaining to the accuracy of the composite Electrical Diagram, a meeting between TSO and the User shall be held as soon as possible, to resolve the difference.

2.9 CONNECTION POINT DRAWING REQUIREMENTS

2.9.1 Responsibilities of TSO and Users

2.9.1.1 TSO shall specify the procedure and format to be followed in the preparation of the Connection Point Drawing for any Connection Point.

2.9.1.2 The User shall prepare and submit to TSO the Connection Point Drawing for the User's side of the Connection Point, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.9.1.3 TSO shall provide the User with the Connection Point Drawing for TSO's side of the Connection Point, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.9.1.4 If the Connection Point is at the User Site, the User shall prepare and distribute a composite Connection Point Drawing for the entire Connection Point. Otherwise, TSO shall prepare and distribute the composite Connection Point Drawing for the entire Connection Point.

2.9.2 Preparation of Connection Point Drawings

2.9.2.1 The Connection Point Drawing shall provide an accurate record of the layout and circuit connections, ratings and identification of Equipment, and related apparatus and devices at the Connection Point.

2.9.2.2 The Connection Point Drawing shall indicate the Equipment layout, common protection, control and auxiliaries. The Connection Point Drawing shall represent, as closely as possible, the physical arrangement of the Equipment and their electrical connections.

2.9.2.3 The title block of the Connection Point Drawing shall include the names of authorized persons together with provision for the details of revisions, dates, and signatures.

2.9.3 Changes to Connection Point Drawings

2.9.3.1 If TSO or a User decides to add new Equipment or change an existing Equipment Identification, TSO or the User , as the case may be, shall provide the other party a revised Connection Point Drawing, at least one month prior to the proposed addition or change.

2.9.3.2 If the modification involves the replacement of existing Equipment, the revised Connection Point Drawing shall be provided to the other party in accordance with the schedule specified in the Amended Connection Agreement.

2.9.3.3 The revised Connection Point Drawing shall incorporate the new equipment to be added, the existing Equipment to be replaced, or the change in Equipment Identification.

2.9.3.4 TSO and the User shall, if they have agreed to do so in writing, modify their respective copies of the Connection Point Drawings to reflect the change that they have agreed on, in accordance with the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.9.4 Validity of the Connection Point Drawings

2.9.4.1 The composite Connection Point Drawing prepared by TSO or the User, in accordance with Section 2.8.1.4 of this Grid Code, shall be the Connection Point Drawing to be used for all operation and planning activities associated with the Connection Point.

2.9.4.2 If differences arise pertaining to the accuracy of the composite Connection Point Drawing, a meeting between TSO and the User shall be held as soon as possible, to resolve the difference.

2.10 GRID DATA REGISTRATION

2.10.1 Data to be Registered

2.10.1.1 The data relating to the Connection Point and the User Development that are submitted by the User to TSO shall be registered according to the following data categories:

(a) Forecast Data;

(b) Estimated Equipment Data; and

(c) Registered Equipment Data.

2.10.1.2 The Forecast Data, including Demand and Active Energy, shall contain the User's best estimate of the data being projected for the five (5) succeeding years.

2.10.1.3 The Estimated Equipment Data shall contain the User's best estimate of the values of parameters and information about the Equipment for the five (5) succeeding years.

2.10.1.4 The Registered Equipment Data shall contain validated actual values of parameters and information about the Equipment that are submitted by the User to TSO at the connection date. The Registered Equipment Data shall include the Connected Project Planning Data, which shall replace any estimated values of parameters and information about the Equipment previously submitted as Preliminary Project Planning Data and Committed Project Planning Data.

2.10.2 Stages of Data Registration

2.10.2.1 The data relating to the Connection Point and the User Development that are submitted by a User applying for a Connection Agreement or an Amended Connection Agreement shall be registered in three (3) stages and classified accordingly as:

(a) Preliminary Project Planning Data;

(b) Committed Project Planning Data; and

(c) Connected Project Planning Data;

2.10.2.2 The data that is submitted at the time of application for a Connection Agreement or an Amended Connection Agreement shall be considered as Preliminary Project Planning Data. This data shall contain the Standard Planning Data and the Detailed Planning Data specified in Section 4.6 of this Grid Code, when required ahead of the schedule specified in the Connection Agreement or Amended Connection Agreement.

2.10.2.3 Once the Connection Agreement or the Amended Connection Agreement is signed, the Preliminary Project Planning Data shall become the Committed Project Planning Data, which shall be used in evaluating other applications for Grid connection or modification of existing Grid connection and in preparing the Transmission Development Plan.

2.10.2.4 The Estimated Equipment Data shall be updated, confirmed, and replaced with validated actual values of parameters and information about the Equipment at the time of connection, which shall become the Connected Project Planning Data. These data shall be registered in accordance with the categories specified in Section 2.10.1 of this Grid Code and shall be used in evaluating other applications for Grid connection or modification of existing Grid connection and in preparing the Transmission Development Plan.

2.11 Data Forms

TSO, shall develop the forms for all data to be submitted in accordance with an application for a Connection Agreement or an Amended Connection Agreement.

2.12 Connected Plant Restrictions

2.12.1 General Principle

Users connected to the Grid can cause power disturbances, which propagate to the power System. If these disturbances are severe, the power System and other Users on the System will be adversely affected as described in Section 3 of this Grid Code. To ensure System integrity and fairness to all Users, restrictions and controls have to be placed on Users of the System.

2.12.2 Safety

The term "Safety" refers to safety standards and procedures adopted in manufacture, erection, choice of location, installation, operation and

maintenance . The term applies both to safety to persons (utility staff and general public) and equipment. The equipment of the Users, including machines, devices, overhead lines, underground cables, transformers, etc., must conform to TSO Electrical Safety Rules, National and Regional Standards; and other Regulatory and Statutory instruments such as Factories and Works Act , regulations and rules that may from time to time be in existence in Lesotho. In addition, where such standards, regulations or rules are not in place applicable international standards shall be used in the interim pending development of national standards.

2.12.3 Insulation

The users' System must be designed with the proper basic insulation level (BIL). Insulation of all components in service must have adequate dielectric strength for the System operating voltages at all times.

2.12.4 Clearances

All overhead lines, equipment and facilities of the User's System connected to the Grid must comply with clearance limits published in the LEWA Electricity Supply Rules.

2.12.5 Earthing

All components of the Users' Systems must be properly earthed as specified in the LEWA Electricity Supply Rules from time to time. All individual earth electrodes, earthing pits, and the interconnection arrangements shall be as per standards and shall be properly maintained.The bodies/ cases/ tucks/ enclosures of all items of equipment shall be properly earthed, with the actual earthing arrangements depending on the machine ratings. Metallic supports of overhead lines and cable sheaths and shields shall also be earthed as appropriate.

2.12.6 Safety Training

Personnel of all entities shall be adequately trained in the correct operating techniques and safety precautions as per the requirements of the LEWA Elecricity Supply Rules.

2.12.7 Access by TSO

TSO and its authorized personnel shall have the right to inspect the plant of

any User to ensure conformity to standards and restrictions.

2.12.8 Unintended and Unscheduled back- energisation

The Users shall take adequate precautions to ensure that no part of the Grid is energized by the User's System from another source of supply unless it is requisitioned in writing by the TSO as an exceptional arrangement . The switchgear and controls of the Users' Systems shall be so designed as to prevent back-energisation and the personnel shall be made aware of the need for this precaution.

2.12.9 Site And Equipment Identification

2.12.9.1 Site and Equipment Identification Requirements

a) TSO shall develop and establish a standard system for Site and Equipment Identification to be used in identifying any Site or Equipment in all Electrical Diagrams, Connection Point Drawings, Grid operations instructions, notices, and other documents.
b) The identification for the Site shall have a unique identifier for each substation where a Connection Point is located.
c) The identification for Equipment shall be unique for each transformer, transmission line, transmission tower or pole, bus, circuit breaker, isolator, earthing switch, capacitor bank, reactor, lightning arrester, and other HV Equipment at the Connection Point.

2.12.9.2 Site and Equipment Identification Requirements Label

a) TSO shall use standard labelling system,which specifies the dimension, sizes of characters, and colours of labels, to identify the Sites and Equipment as specified in LEWA Electricity Supply Rules.
b) TSO or the User shall be responsible for the provision and installation of a clear and unambiguous label showing the Site and Equipment Identification at their respective Systems.

SECTION 3

PERFORMANCE STANDARDS CODE

3 POWER QUALITY STANDARDS

3.1 Introduction

This Section specifies the electrical parameters of performance of the Grid, which affect the performance of connected Users, and other Transmission Systems interconnected to the Grid.

3.2Purpose and Scope

- To ensure that the Grid performance meets a minimum standard which is essential for TSO and the User's System and equipment to function properly.

- To enable Users to design their systems and equipment to suit the electrical environment that they operate in.

The Grid performance standards apply to:

a) TSO.
b) DSO.
c) Any generator connected to TSO System.
d) Any User connected to or intending to be connected to TSO System.
e) Any other Transmission System within or outside Lesotho connected or intending to be connected to TSO System.
f) Any provider of Ancillary Services to the Transmission System.

3.3 Power Quality

Power quality shall be as defined in LEWA Quality of Supply Standards as amended

3.3.1 Frequency Variations

Frequency of the Transmission System should be maintained within an acceptable range to ensure proper operation of the System. The nominal frequency shall be 50 Hz. During normal and emergency conditions the following frequency ranges shall apply

Table 3.3.1 Frequency Limits

Statutory limits	
Upper limit:	50.5 Hz
Lower limit	49.5 Hz

3.3.2 Harmonics

Harmonics have many negative effects on the System and connected loads, so they have to be limited to a manageable level . Control of harmonics on TSO System is based on voltage harmonic distortion. Harmonics are grouped into three categories: odd triplens (multiples of three), other odd harmonics, and even harmonics, with different severity levels and effects on equipment for each category. Odd harmonics are much more common than even harmonics.

3.3.2.1 Limits

Wherever necessary the harmonics limits shall be calculated and set as per PIESA 1048 Standard or IEC/TR3 61000- 3- 7 standard as per Table 3.3.2 below.

Table 3 .3 .2

Maximum Limit s of Voltage Harmonic Distortion in HVSystems

Harmonic Order	Distortion	
	HV	EHV
(Odd, non-triplen)		
5	6.0	2.0
7	5.0	2.0
11	3.5	1.5
13	3.0	1.5
17	2.0	1.0
19	1.5	1.0
23	1.5	1.0
25	1.5	0.7
>25	0.2+1.3x25/n	0.1+0.6x25/n
(Odd, triplen)		
3	5.0	2.0
9	1.5	1.0
15	0.3	0.3
21	0.3	0.2
>21	0.2	0.2
(Even)		
2	2.0	2.0
4	1.0	2.0
6	0.5	0.5
8	0.5	0.4
10	0.5	0.4

12	0.2	0.2
>12	0.2	0.2
Total Harmonic Distortion .	8%	3%

n* harmonic order

3.3.2.2 Control and Measurement

Measurements may be taken at any time by TSO at the customers Connection Point. Measurements have to be taken in accordance with methodologies of PIESA 1048.

3.3.3Voltage Variations

The main Grid voltages shall be kept within the following limits in steady state and contingency operating conditions.

Table 3.3.3: Voltage Variations

Normal Conditions		Emergency Conditions		
Nominal Voltage (kV)	**Maximum (KV**	**Minimum (KV)**	**Maximum (KV)**	**Minimum (KV)**
132	138.6	125.4	145	118.8
88	92.4	83.6	96.8	79.2
66	69.3	59.4	72.5	56.1
33	34.7	31.4	36.3	29.7

3.3.4 Voltage Unbalance

The phase voltages of a 3-phase supply should be of equal magnitude and 120^{o} apart in phase angle. Deviations will result in decreased efficiency, negative torque, vibrations and overheating. Severe unbalance could lead to malfunctioning of some equipment. Voltage unbalance is defined as:

$$\text{Voltage Unbalance} = \frac{\text{Deviation between highest and lowest phases}}{\text{Average voltage of three phases}}$$

Balancing loads on individual phases will help greatly in avoiding unbalanced voltages.

3.3.5 Voltage Fluctuation and Flicker Severity

If the voltage fluctuates, the luminous intensity of the lamps and TVs will

fluctuate correspondingly. If the fluctuation is of a magnitude and frequency perceptible to the eye, it becomes flicker. Flicker could range from annoying to complete interference of normal activity. Flicker is not usually produced by the power System but by customer loads such as arc furnaces, compressors, starting of large motors, etc. Since voltage fluctuation of the System affects other users on the same System, TSO shall direct the management of flicker on its lines and station buses. At the same time, flicker-generating loads connected to the System have to be controlled. TSO reserves the right to disconnect any excessive flicker generating load until the Grid User rectifies the problem.

3.3.5.1 Indicator of Quality for System Flicker

Flicker is the impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time. It is generated by customers and is indicated by the short-term flicker severity index Pst, as defined in IEC Standard 61000-3-7 and measured with a flicker meter that meets the specification of IEC Standard 868 or IEC Std 61000-4-15. For the purpose of regulation, P_{st}, the short-term flicker severity index, is selected as the indicator of quality. Pst is considered to be the measure of visual severity of flicker derived from a time series output of a flicker meter over a ten-minute interval.

3.3.5.2 Limits

Pst = 1, which is equivalent to the threshold of perception, is the allowable level of flicker on the Transmission System. Tolerance for customer-generated flicker varies with the relative strength (short circuit ratio) of the load and voltage level. Limits are given in the following table.

Table 3.3.5:

Limits of flicker produced by Users

Short Circuit Ratio (SL/SCC)	Voltage	Pst
SL/SCC > 0.04	HV	0.37
SL/SCC ≤0.04	HV	0.8

3.3.5.3 Monitoring Control and Measurement

Substations, which supply heavy industrial loads are targets for flicker monitoring.Other substations and Connection Point will be selected for monitoring on a random basis.

3.4 Reliability Standards

System reliability of the Grid includes three aspects:

System adequacy
System security
Service reliability

The compliance to System adequacy and security reliability standards shall be as specified in Section 4 of this Grid Code.

3.4.1 Service Reliability

The points where electric power is supplied from the Transmission System to the Users (distribution companies, another Transmission System) are called delivery points or Grid supply points. Outages at these points directly affect the Users of the Grid. The reliability level at the delivery points is therefore an indication of the quality of service provided by TSO to its Users.

Service reliability of the Grid is indicated by:

a) Number of loss of supply incidents at the delivery points
b) Average duration of loss of supply incidents at the delivery points

These service reliability parameters will be determined for individual delivery points and be agreed between TSO and Users.

Note: Scheduled outages, which are communicated to the customers beforehand and load shedding due to capacity shortage, are not counted.

3.5 Power Factor

3.5.1 General description

It is desirable that loads on the System have power factors at or close to unity as that represents the most efficient use of the System capability and the least loss of energy. It also eliminates many transient stability problems. Any load with a power factor lower than 93% is imposing an unfair burden on the Transmission System and other Users.

3.5.1.1 Limit

The minimum power factor allowed is 93%.

3.5.1.2 Control and Measurement

Power factor measurements are made continuously in conjunction with the voltage measurements. Loads with inherent low power factors should automatically include power factor correction equipment to correct the problem.

3.5.1.3 Penalty

A user with power factor worse than 93 % may be refused connection to the transmission Grid until the problem is rectified. Alternatively, a penalty will be imposed based on load level and annualised cost of power factor correction capacitors.

3.5.2 Reactive Power Requirements

In general the Distribution Companies shall not depend on TSO for reactive power support. DSO and other Grid Users shall provide reactive compensation for their System. DSO and other Grid Users shall ensure that customers having inductive load install capacitors so that at the interface with TSO the power factor is not less than 93%.

SECTION 4

PLANNING CODE

4.1 Introduction

Provisions of this Section are intended to enable TSO to produce a System Development Plan and a Power Development Plan for demand and supply balance. This will be done in consultation with all Grid Users in order to ensure an efficient, coordinated, secure and economical Grid and power developments that will satisfy future demand requirements. The Section identifies the planning requirements for the Transmission and Transmission Systems and the Generation System including Imports options. These will include the planning criteria, the planning processes and the tools to be used.

The addition of a new facility or the modification of an existing facility on the Transmission System may have a significant impact on the operation of the system. The impact needs to be analysed prior to the addition or modification of facilities.

4.2 TRANSMISSION SYSTEM PLANNING CRITERIA

It is essential that the Transmission System is designed to ensure adequate, secure and acceptable reliability levels, that is, it should meet the (N-1) reliability criteria.

4.2.1 Voltage Levels

The Lesotho Transmission System comprises the 33 kV, 66 kV,88 kV and the 132 kV networks and interconnects to other SAPP utilities.

4.2.2 Normal Operation

With all transmission lines in service, the System must be capable of a satisfactory supply of all bulk supply points both during peak and light load conditions. Switching off lines for voltage control during light load is accepted as long as this is not detrimental to the overall reliability.

4.2.2.1 Loading Limits

Thermal designings shall not be exceeded in steady state operation. These line ratings will be as per TSO designs as shown below and updated from time to time.

Table 4.3.2a

Conductor Current Rating (MVA) for the Transmission System Different Maximum

Conductor Temperatures.

Conductor (mm^2)	Voltage (kV)	50 °C (MVA)	65 °C (MVA)	75 °C (MVA)	80 °C (MVA)
Racoon (75)	66	16.5	30	36	-
	88	21.9	40	47	-
Dog [1]* (100)	66	18.6	36	42	-
	88	24.8	48	56	-
	132*	37	71	84	-
Wolf (150)	66	21.7	45	54	-
	88	29	61	72	-
	132	43	91	108	-
Twin Wolf (2x150)	88	58	121	144	-
	132	87	182	216	-
Single Lynx (175)	66	22.7	50	59	-
	88	30.3	66	79	-
	132	45	99	118	-
Twin Lynx (2x175)	88	61	132	157	-
	132	91	198	236	-
Single Panther (200)	66	23.8	54	64	-
	88	31.7	72	86	-
	132	48	108	128	-
Twin Panther (2x200)	132	95	215	257	-
Bear [2]* (250)	132	50	122	146	128
Single Bison (350)	88	-	100	120	193
	132	-	149	179	385
Twin Bison (2x350)	132	-	299	359	963

Thermal design ratings shall not be exceeded in steady state operation.

4.2.2.2 Voltage Limits

In steady state operation, main Grid voltages shall be kept within the following limits:

Nominal (kV)	Maximum (kV/p.u.)	Minimum (kV/p.u.)
132	138.6/1.05	125.4/0.95
88	92.4/1.05	83.6/0.95
66	69.3/1.05	62.7/0.95
33	34.6/1.05	31.4/0.95

4.2.3 Outage Conditions

The following outage criteria apply to the operation of the interconnected Transmission System. In general, the criterion requires that there shall be no loss of load for Single Outage Contingency.

4.2.3.1 Stability Criteria

The System shall remain stable for a single line to ground fault with unsuccessful high-speed three pole re-close and definite three pole tripping.

The System shall withstand a sudden outage of any generating unit or block of units connected to the same transformer without loss of supply. (However, load shedding following an outage of the whole power station is accepted).

4.2.3.2 Loading Limits

For a single outage, the following load limits shall be applied once the new steady state has been reached, but prior to any operator intervention.

a) Short-time (10 minutes) overloads of up to 15% on transmission lines shall be accepted if generationrescheduling is available (i.e. before operator action canbe taken).

b) Short-time (10 minutes) overloads of up to 15% on transformers shall be accepted.

Limited overloads for short periods are not considered to bring the conductor temperature to critical values neither are they expected to increase sags too much.

4.2.3.3 Steady State Voltage Limits

For a single outage, the following voltage limits shall be applied once the new steady state has been reached, but prior to any operator intervention.

- Main Grid voltages shall be kept within:

Nominal (kV)	Maximum (kV/p.u.)	Minimum (kV/p.u.)
- 33 kV:	36.3/1.10	29.7/0.90
- 66 kV:	72.6/1.10	59.4/0.90
- 88 kV:	96.8/1.10	79.2/0.90
- 132kV:	145.2/1.10	118/0.90

4.2.3.4 Transient Voltage Deviations

The transient response of the System following a disturbance shall be investigated if bus voltages swing outside the range of 0.8 to 1.2 p.u.for more than 500 milliseconds.

4.2.3.5. Transformer Loading Limits

The following transformer loading limits shall be applied following transformer outages.The set limits are based on IEC standards 38 or TSO design, assuming an ambient temperature of 30 deg. C. Momentary loading based on I EC standards 38 or TSO design is for a period of 30 minutes.

Table 4.3.4: 132 kV, 88 kV, 66 kV and 33kV Transformer Loading (MVA)

TRANSFORMER NAMEPLATE RATING (MVA)	LOADING LIMIT (MVA) MOMENTARILY MOMENTARILY CONTINUOUSLY	NOMINAL CAPACITY(MVA)
40MVA(ONAN)	50	40
20MVA (ONAN)	25	20
10MVA (ONAN)	12.5	10
5MVA (ONAN)	6.3	5

4.2.4 Other Criteria

4.2.4.1 Losses

Costs of losses shall be evaluated as part of the economic analysis of the different Transmission System alternatives. The analysis shall include evaluations on optimum line design (voltage , conductor type and configuration).

4.2.4.2 Wayleaves and Clearances

The standard way leaves shall be as follows: -

Normal operating voltage	Wayleave width
11kV	8 m
22 kV	8 m
33 kV	13 m
66 kV	14 m
88 kV	16 m
132 kV	18 m

In addition, the following line clearances in metres shall be observed: -

Normal operating voltage between line conductors (in kV)(inmetres)	Over roads (inmetres)	Minimum ground clearances
Up to and including 33	6.5	5.5
66	6.9	6.3
88	7.5	6.3
132	7.5	6.3

4.2.4.3 System Protection Schemes

i. Each User shall take all reasonable steps to protect its own plant.

ii. All plant connected directly to a TSO Grid shall comply with the Grid Code protection requirements described in section 7. Further detailed protection applications, insofar as the equipment of one User may have an impact on another, shall be agreed to in writing by the relevant User. Users that have customers connected directly to the TSO Grid are responsible for ensuring that such customers comply with the relevant protection standards.

iii. The User shall co-operate to ensure adequate protection co-ordination.

iv. Customer's protection dependability shall not be less than 99% and the customer shall ensure that QOS standards are adhered to.

4.2.4.4 Steady State Stability Limits

When evaluating the System's transfer limits, care should be taken to design the System with adequate margin to voltage collapse phenomena. Transfer limits must ensure that a single outage does not bring the System into instability situation. The System should be regarded as unacceptable from a planning point of view if it runs out of voltage control range following a single contingency.

4.2.4.5 Maintenance Restrictions

The proposed "N - 1" criterion used for the Transmission System does not take into account outages due to maintenance. The reason is that it has been assumed that no major maintenance will be carried out during peak load, which is considered to determine the design of the System. Depending on circumstances, it might be necessary for the planner to evaluate the System even for "N - 2" conditions, and weigh costs and benefits of designing the System to meet such a criterion.

In general, when evaluating different development strategies, those alternatives that are foreseen to better meet requirements during maintenance, should be preferred.

4.3 NETWORK DEVELOPMENT APPROACH AND METHODOLOGY

4.3.1 Objectives

This Section presents the approach and methodology to be adopted in the transmission planning process in TSO. The aim is to lay a framework for

the planning aspects involved in transmission and Transmission System planning covering the required inputs, the expected constraints, the expected results and the basic steps to be taken.

The planning and design of the Transmission System is aimed at producing a network that is capable of transmitting electrical energy from the generating plants to the load centres in an economic, safe and reliable manner .

4.3.2 Approach

The normal approach in network planning is to carry out a technical analysis on the most promising development plans based on attaining certain reliability levels.

Transmission System reliability levels should be analysed using planning criteria that define allowable system responses. The criteria should be stringent enough to ensure a high quality of supply yet it must also be realistically cost effective in today' s competitive environment. The criteria may be based on either deterministic or probabilistic approaches. The deterministic approach involves the specifying of allowable System response to specified contingencies or disturbances. Probabilistic approach involves limiting the risk of System failure or even limiting customer impact such as risk of loss of load, on the basis of outage statistics of System components.

Recent years have seen several developments in probabilistic reliability assessment procedures, which have been used to substantiate the need for System expansions. These have now been applied widely by some utilities. Reliable and detailed data for making failure models for most System components have been established having been assisted by reliability-based maintenance approaches being used in operating the network. However , the deterministic approach is viewed as adequate for the Lesotho System.

The criteria developed apply to both static and dynamic conditions, requiring that the System response to certain disturbances fall within prescribed limits. These limits often specify permissible voltage ranges, component loadings, frequency deviations and rotor angles. The limitation of the deterministic approach is that it does not provide a means of quantifying the worth of improved supply, which is required to justify System reinforcements. The deterministic approach is considered to be the best for the TSO System.

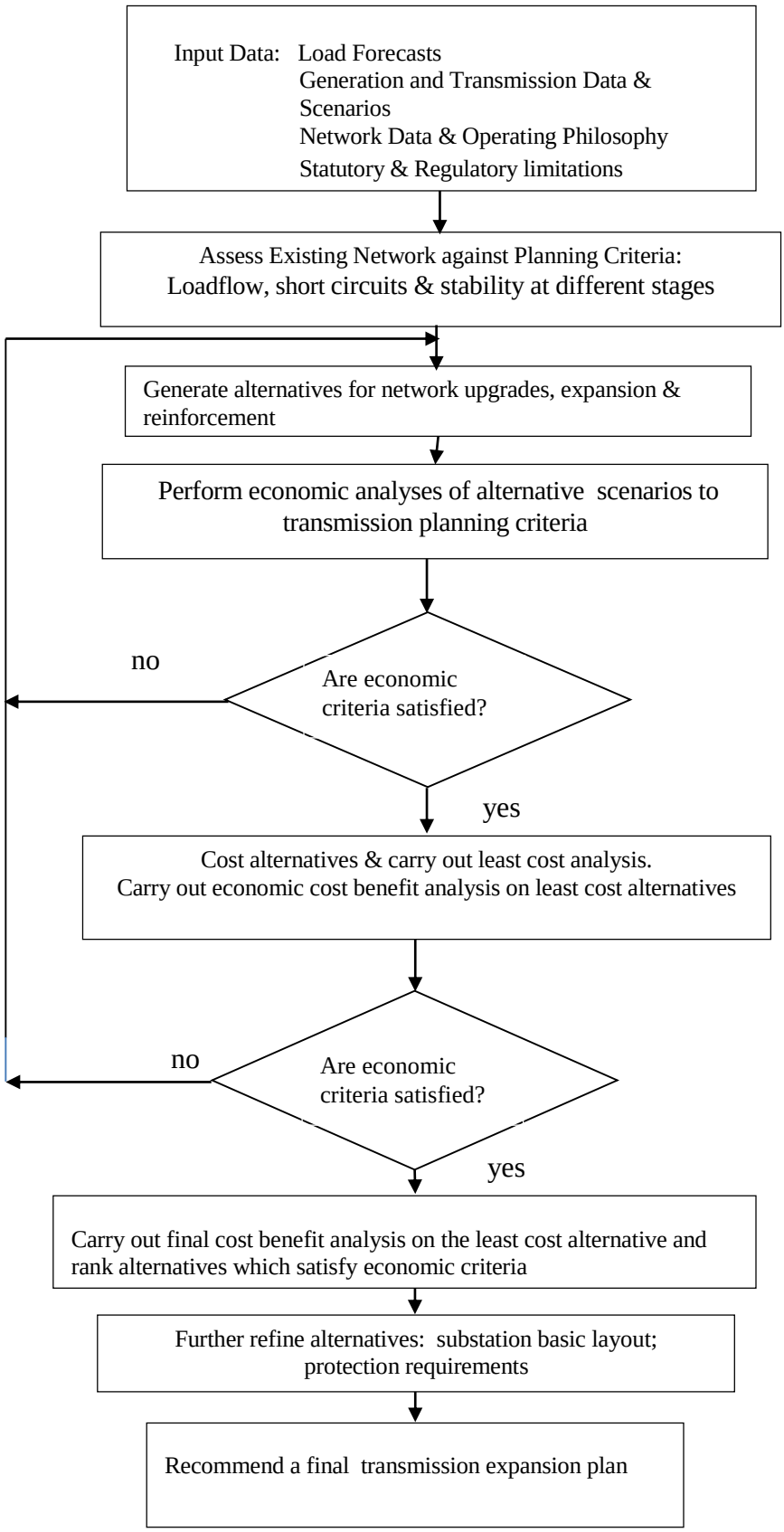
4.3.3 Methodology

4.3.3.1 Basis

The System Transmission System developments plans shall be based on load forecast, Transmission and Generation System development plan and agreements for transactions with other utilities and regions internal or external to the country. Any external factors that might affect Transmission System planning should be addressed in the planning process.

Figure 4.4.3 illustrates the stages that are involved in the transmission planning process. An essential feature of this process is the screening of alternatives from an economic and technical point of view to avoid carrying out detailed studies on alternatives that are not competitive. The number of alternatives to be investigated is therefore reduced from one stage to the other. The remaining alternatives are then subjected to more detailed studies.

Figure 4.4.3 Stages in the Transmission Planning Process.



4.3.3.2Grid Planning Studies - Technical Analysis

TSO shall carry out Grid planning studies to ensure Reliability, Safety, Security and Stability of the Grid for the following:

i. Preparation of the Transmission Development Plan (TDP) to be integrated with the Power Development Plan (PDP).
ii. Evaluation of the Grid reinforcement projects and
iii. Evaluation of any proposed User Development , which is submitted to the TSO in accordance with the application for connection.

The Grid planning studies shall be conducted periodically to assess the behaviour of the Grid during normal and outage conditions; and also during transients induced by disturbances. The first screening process is through the technical analysis of the identified transmission expansion alternatives. The required inputs for this process are:

a) load forecasts
b) existing network
c) committed generation and transmission expansion plans
d) generation and transmission scenarios
e) transactions with other utilities

The need for transmission expansion plans is detemined by identifying any transmission constraints, in future based on the input data. Basic alternative development plans that would solve these problems are listed and engineering judgement is applied to screen these alternatives and remain with the best.

The best alternatives are assessed for their technical soundness against the planning criteria discussed above. The techniques applied ensure that all components are operating within prescribed limits and that voltages are within permissible ranges. Load flow analysis techniques are used at this stage of the process. For networks with obvious transient stability problems, initial investigations of System dynamic response will also be carried out at this stage. Fault analysis shall be carried out at a later stage of the planning process. System reliability analysis shall be required as a basis for evaluating alternatives.

Transmission planning studies must be performed as necessary to determine the impact on the interconnected Transmission System when connecting new and/or modified generation, transmission, or end-use facilities to ensure the security and adequacy of the Transmission System. The results of these

analyses will be used to determine if modifications must be made to maintain the reliability of the Transmission System. A detailed interconnection study is made up of the following components:

i. Load Flow Analysis
ii. Fault Analysis
iii. Stability Analysis

a) Load Flow Analysis

A model of the power System is used to simulate certain specified operating conditions. Load flow studies shall be performed to evaluate the behaviour of the existing and planned Grid facilities under forecasted maximum and minimum load conditions and to study the impact on the Grid of the connection of new generation plants, loads or transmission lines. The results predict power flow magnitudes and voltage levels under the loss of any individual System element . The load flow analysis enables the prediction of equipment overloads and the determination of excessive steady state voltage drops, which may be encountered.

b) Fault Analysis

Fault analysis is performed to determine the effect of equipment additions or modification on the System fault currents. The studies also identify the most severe conditions that the Grid equipment may be exposed to. The fault studies data is used to evaluate the impact of the new or modified installation on the interrupting capability or rating of the previously installed equipment such as circuit breakers and switches.

TSO shall maintain an up to date fault level database, which should be made available on request by Grid Users. TSO shall inform the Grid User , if fault levels at a Connection Point are likely to impact adversely on the User's Equipment connected to the Grid.

c) Stability Analysis

Stability analysis is performed to determine the Transmission Systems response to a sudden change in the state of the System due to faults on the System and unit outages. The stability analysis will determine:

i. Unit / station stability during faults
ii. Voltage levels and deviations
iii. Frequency levels and deviations

iv. Synchronous generator rotor oscillations, real and reactive power outputs

4.3.3.3Economic Analysis

Electricity plays a major role in the economic development of the country as a whole. Therefore the Transmission Development Plans that result in a reliable network are core elements in the strategy for raising the economic and social welfare of citizens. This involves demonstrating that the proposed project is likely to contribute significantly to the development of the entire economy to justify the use of the resources envisaged for the project.

Cost-benefit analysis provides a tool for assessing the worth of a project to society.Where alternative projects are aimed at satisfying the same objective, cost benefit analysis shall be used to compare the alternatives. In transmission planning, least-cost analysis should be used to eliminate some alternative expansion plans.

4.3.3.4Environmental Analysis

The environmental analysis focuses on the project's impact on the environment , both human and bio-physical, during construction, operation and de-commissioning. The environmental impact study should provide baseline information to be used in monitoring environmental impacts and assessing the effectiveness of mitigating measures. Both negative and positive environmental impacts should be identified and quantified to the extent possible.

4.3.3.5Financial Analysis

Financial analysis of a project involves determining the cost and revenue of the project . The costs give an indication of the funds needed to complete the project , while the revenue and sources of funds determine whether a project can sustain its financial obligations and have adequate working capital as well as generate sufficient cash flow to meet the project operational expenses.

The technique provides a measure of the profitability of the project. Financial analysis should only be carried out on the screened alternatives that have been proved to be economically viable.

4.3.3.6Final Selection

The final transmission projects that would have gone through the above stages will then be incorporated in the System Development Plan (SDP).

4.3.3.7 Transmission Planning Tools

TSO shall employ planning tools that are currently available in the market. It is preferable that the users employ the same tool as TSO to facilitate smooth data exchange.

4.4POWER GENERATION DEVELOPMENT PLAN

The objective of a Power Development Plan is to establish when, where and what type and size of plant to build, in order to ensure an economic and reliable supply of forecasted load within a given planning period.

Thus four basic questions have to be answered in the course of the planning process.

These are:

i. WHAT capacities to install to ensure demand and supply balance?
ii. WHAT capacities to install to ensure an appropriate level of reliability? HOW to pick the best combination among the different technologies at hand now and in future?
iii. WHEN is the proper time to incorporate them into the System?

4.4.1 Planning Approach

TSO shall use a Least Cost Planning approach. A practical framework for least - cost utility planning should explicitly consider the major issues in resource planning and facilitate risk management . In this framework, demand and supply side options are simultaneously evaluated for cost effectiveness.

The model to be used for integrated demand, supply and financial planning shall perform the following functions:

i. Optimise supply side options for conventional and renewable resources over the entire planning horizon.
ii. Optimise demand side options including conservation and peak reducing programs.
iii. Select new plants and Demand Side Management programmes to satisfy emission restrictions on SOx, NOx and particulates.
iv. Satisfy reliability requirements to meet the reliability criteria.

4.5. LOAD FORECASTING

Electricity power supply and demand must be balanced at all times and the challenge for any electricity supply company is to provide a reliable electricity supply service at least cost . To meet this challenge it is necessary to plan for a level of investment that meets future energy consumption and maximum demand given by a load forecast.

The major uncertainties in forecasting and planning should be explicitly recognised in the planning process. In order to minimise load-forecasting uncertainties, the load forecast for generation planning shall mainly comprise the base case, low case and high case as provided and updated by TSO on an annual basis or when the need arises.

Demand and energy forecasting is mainly classified into three ranges: short (1 year), medium (5 years) and long-term (20 years). The short term forecast is useful in determining unit commitment and economic dispatch; medium term forecasting is required for fuel procurement, maintenance scheduling and diversity interchanges; whereas the long- term forecast (annual peak and energy consumption forecast) is necessary for System expansion planning and financial analysis. Energy and demand are forecast on an annual basis for the 20-year planning period so as to provide a sufficient time horizon in providing future development options. TSO shall employ current load forecasting software, which includes but not limited to Model for Analysis of Energy Demand (MAED).

4.5.1. Satisfying the Load Forecast / Developing Scenarios

After the Load Forecast is produced it is matched against the capacity and energy resources of the existing plants to see whether they can satisfy the requirements over the planning period. If the existing plants cannot meet the load forecast it then becomes necessary to find the best possible ways of meeting the demand reliably and at least cost , which is what Power Development Planning is all about. Technically equivalent scenarios have to be evaluated to determine the least cost , taking into consideration three major criteria:

a) Criterion 1 (Reliability Criterion)

The minimum reserve level to be carried on the System shall be as per SAPP Generation Plan.

b) Criterion 2 (Security Criterion)

The minimum level of internal generation shall have as a long-term objective, capacity equal to or greater than 100% of demand. Internal generation shall be committed when existing reserve levels drop below Criterion 1.

c) Criterion 3 (Economic and Financial Criterion)

For economic considerations Firm Imports may exceed the reserve margin limit as long as Criterion 2 is met.

4.5.2 Demand Side Management (DSM)

Customer demand can be influenced by utility actions. Demand-side options are available, viable and potentially useful alternatives to traditional generation-based strategies. Demand side management is the planning and implementation of those utility activities designed to influence customer use of electricity in ways that will produce desired changes in the utility's load shape. The rationale for DSM as a part of overall utility planning is:

- The demand for electricity is within utility's control .
- The timing and shape of load can be influenced by direct utility action in ways that contribute to meeting utility objectives.
- Demand side options can be used to complement or substitute supply-side options.

The benefits are the savings in avoiding energy supply costs. These avoided costs are the marginal costs of the supply resource replaced by DSM . They include the reduction of transmission, distribution, generation and capacity costs for periods when the load has been reduced.

4.5.3 Options Available

All available options such as, but not limited to the following shall be considered in the optimised generation expansion plan.

- Hydro options
- Thermal options Imports
- Non conventional and renewable energy sources

4.5.4 Operating Environment

The characteristics of the utility planning environment suggest four principles for improved decision making:

- Evaluate decisions as they affect customers and investors.
- Analyse the effects of uncertain variables on the customer ' s cost of service and the investors' return.
- Consider the long - term consequences of investment decisions for the relevant range of uncertainties and for major contingencies.
- Ensure that decisions are well documented with supportive studies and rationale for the purposes of public and regulatory retrospective review.

4.6 PLANNING DATA EXCHANGE

In order to ensure adequate planning and development of the Transmission Grid, TSO will require information pertinent to planning that may be resident in other companies such as DSO and any other customers connected to the Grid and any other suppliers of power in the Grid. TSO should have full access to all the relevant data from these companies as and when the need arises. TSO shall provide standard data format for this purpose. A more detailed account of data requirements is given in Section 8 of this Grid Code. The information requirements shall basically include, but not limited to:

i. Historical Energy and Demand
ii. Energy and Demand Forecast
iii. Dependable Capacity
iv. LEWA and/or SAPP approved criteria
v. DSO or any other User or Customer System Data
vi. Transmission data
vii. Network topology data

SECTION 5

OPERATIONS CODE

5.1 Introduction

TSO is entrusted with the responsibility to transmit power and energy from the gener units and/or imports to the end Users in a safe, reliable and within specified power q parameters. TSO transmission grid is operated in parallel as an interconnected grid other SADC utility transmission networks to form the Southern African Power Pool (SAP pursuance of harmonised interconnected operation the SAPP has developed oper guidelines that are subscribed to by all the operating members. TSO takes cognisan the SAPP requirements in developing and implementing its own guidelines procedures.

5.2 Purpose

This Operations Code is intended to enable TSO to operate a well-coordinated, and secure transmission grid that shall deliver quality power. The code incl guidelines on principles and procedures for providing system services, network switc demand/supply balancing, operational planning and events reporting. These sha done in consultation with all grid users.

The code deals with the following issues: -

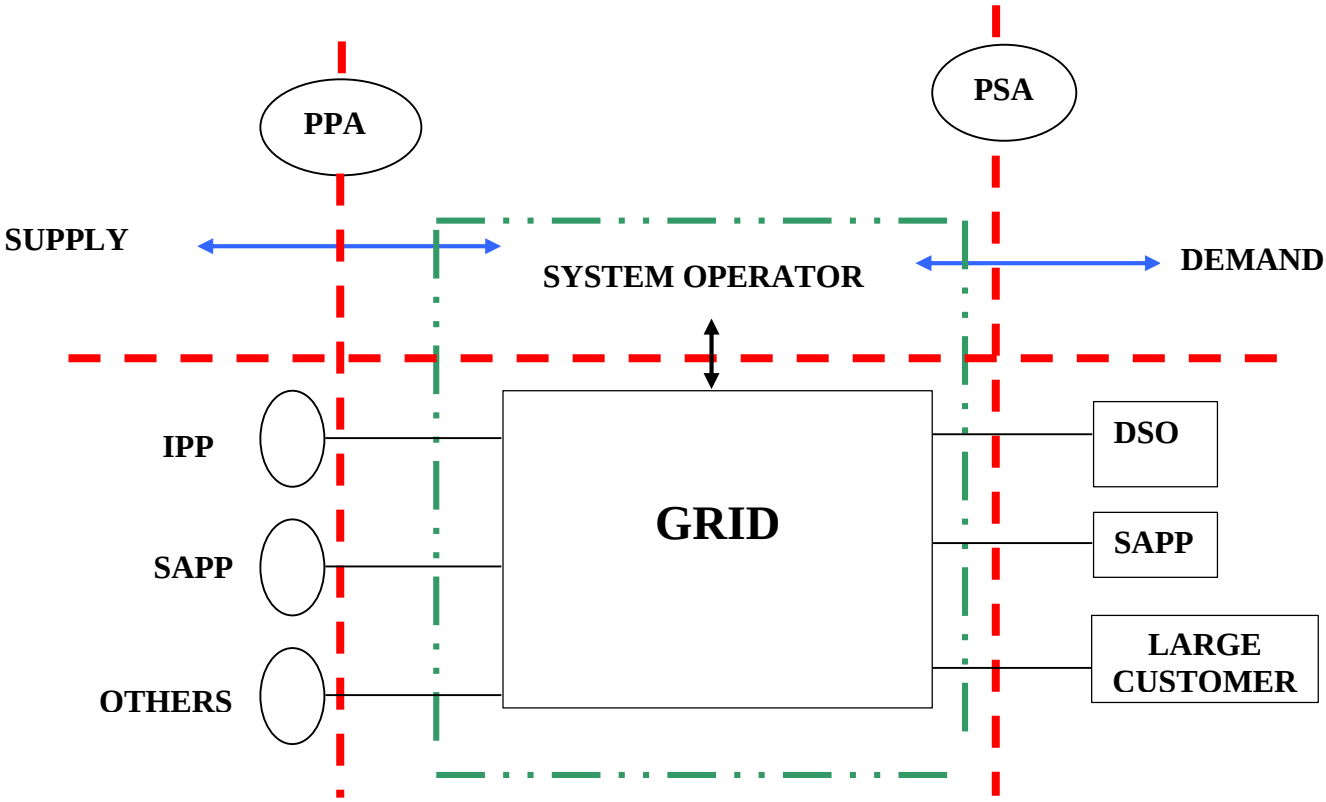
a) Pre-dispatch and post-dispatch planning
b) Real-time system monitoring and control
c) Communication during normal andemergency conditions
d) Maintenance planning, co-ordination and execution.
e) Generation scheduling and dispatch
f) Safety coordination.
g) System disturbance monitoring and analysis.

5.3 Responsibility

Equipment ownership and demarcations shall be as per connection agreem between TSO and the Grid Users. Control, operation and maintenance of any equip shall be as detailed in the Power Supply Agreement (PSA), Power Purchase Agreem (PPA) and any other agreement that TSO may have with any Grid User as illustrat the figure below.

All Grid Users shall endeavor to operate their respective systems in synchronism a times. Safety of personnel and security of power system shall be accorded higher pri

than economic considerations.



5.4 System Monitoring

TSO shall maintain a control centre that is manned 24 hours a day by an appropriate number of personnel for the purpose of system monitoring and control. The control centre must be equipped with a computer based supervisory control data acquisition and energy management system.

For effective operation of the transmission grid, TSO shall continuously in real time monitor the following: -

(a) Actual generation per unit (MW).
(b) Actual active power (MW) drawn by Grid Users
(c) Tie-line interchange
(d) Reactive power (MVAr) flows into or out of TSO grid.
(e) System frequency
(f) Voltage profiles in all stations and points of connection
(g) Equipment loading

Equally important all information on generator trips shall urgently be conveyed to TSO.

5.5 System Services

System services are all services essential for the proper functioning of the transmission grid and which determine power quality. These services include, but not limited to, frequency control , voltage control and operating reserves. TSO shall ensure that the transmission grid is operated with adequate levels of these services. TSO shall advise Grid Users of the required contribution levels of the services where they are mandatory and shall itself , procure adequate levels where TSO has to self provide.

5.5.1 Frequency Control Service

TSO shall operate the grid in a manner that provides adequate frequency control within applicable limits at all times in order to maintain the security and integrity of the same. Both primary and secondary frequency control shall be as per recommendations from TSO/SAPP.

5.5.1.1 Frequency Range

The frequency within the Southern African Power Pool (SAPP) is maintained and controlled jointly by all the interconnected utilities. The normal

frequency shall be 50.0Hz with a statutory range of 48.5Hz and 51.5Hz. The operational range, which is narrower than the statutory band, shall be as recommended by the SAPP or TSO when operating in the interconnected or islanded mode respectively.

5.5.1.2 Frequency Control

a) All generators must operate under the control of a governor system at all times when synchronised to the grid.
b) All governors shall be capable of droop adjustments of between 3% and 6%. The actual governor settings to be implemented for primary frequency control shall be as specified in the connection agreement.
c) No deliberate time delays shall be introduced in the governor control systems.
d) Frequency dead bands shall be as per recommendation from TSO in consultation with SAPP utilities.
e) TSO shall employ Automatic Generation Control (AGC) and manual actions for secondary frequency control. Generators required to be under AGC shall be specified in the connection agreement and those not operating under AGC shall continue to follow dispatch instructions from the System Operator. The AGC shall meet the frequency and tie-line standards defined by SAPP.

5.5.2 Voltage Control Service

Voltages on the grid and at points of connection shall be maintained within the limits specified under section 5 .5 .2 .1 of this Code. In cases where the voltage limits are unique to the point of connection, these shall be as specified in the connection agreements. The duration and extent of voltage fluctuations shall also be limited under fault conditions. TSO shall employ both static and dynamic methods to maintain voltage stability, maintain voltages within limits and minimise system losses using methods that include but not limited to the following.

(a) Transformer tap changing
(b) Reactor and capacitor switching
(c) Static Var Compensators
(d) Generator reactive power capability
(e) Demand management

(f) Transmission lines charging capacitance

5.5.2.1Voltage Range

The main grid voltages shall be kept within the following limits in steady state and contingency operating conditions so as to minimise system losses and to maintain quality of supplies.

	Norminal Condition		Emergency Condition	
Norminal Voltage (KV)	Maximum(KV)	Minimum (KV)	Maximum (KV)	Minimum (KV)
132	138.6	125.4	145	118.8
88	92.4	83.6	96.8	79.2
66	69.3	59.4	72.5	56.1
33	34.7	31.4	36.3	29.7
11	11.6	10.5	12.1	9.9

Where standing instructions or special dispensations are in place the voltage might not follow guiding limits in the table above.

5.5.2.2 Voltage Control

a) Grid voltages will continuously be monitored and controlled accordingly. TSO shall adjust grid voltages using available control facilities.

b) Generator excitation systems shall be normally operated under a continuously acting Automatic Voltage Regulator (AVR) which shall be set to maintain a constant terminal voltage.

c) The TSO shall instruct the generators on what terminal voltage to maintain.

d) Generators may only disable the action of AVR if such action assists in imprving on the reliability of the generator.

e) As an emergency measure TSO may implement load shedding to prevent lower voltage limit excursions.

f) Line switching will be implemented only if it does not jeopardise system security.

5.5.3 Equipment loading

TSO shall continuously monitor the loading on all plant and equipment on the transmission grid. Thermal design ratings shall not be exceeded in steady state operation and for single outage. Short time overloads of up to 15% on transmission lines and transformers shall be accepted if generation rescheduling is available (i .e. before operator action can be

taken). Otherwise TSO shall implement load management to relieve over loaded circuits.

Grid Users drawing power from TSO grid shall ensure that their loads do not affect TSO grid system in terms of causing any:

a) Unbalance in the phase angle and magnitude of voltage at the points of connection beyond the limits prescribed by TSO.
b) Harmonics in the system voltage at the interconnection point beyond the limits prescribed by TSO.

Should any one of the above two prevail, TSO may direct the User(s) to take appropriate measures to remedy the situation.

5.6 Operational Planning

TSO shall be responsible for developing consolidated demand forecast , demand control procedures, outages and contingency plans.

5.6.1 Demand and Supply Planning

All grid Users drawing power from TSO grid shall provide TSO, for all points of connection, with

i. Estimates of demand per month for the year ahead
ii. Estimates of demand per day for the month ahead.

Similarly each generator shall provide TSO with estimates of generation availability per month for the year ahead and per day for the month ahead.

TSO shall match the consolidated demands with consolidated generation availability and plan for demand control to ensure that there is a balance between the available power / energy and the demand (inclusive of system losses and required reserves).

5.6.2 Outage Planning

TSO and each User shall prepare an outage programme for the ensuing financial year for compilation of the overall outage plan for TSO grid. Each User shall obtain approval from TSO prior to availing the outage. However , TSO is authorised to defer any planned outage in case of any of the following events: -

a) Major grid disturbance

b) Security constraint dispatch
c) Unavailability of other equipment that has to be conditionally in service for the outage to go ahead
d) Any other event in the system that may have an adverse impact on system security by the proposed outage.

5.6.3 Contingency Planning

The contingency plan and Black Start procedures shall be prepared by TSO in consultation with grid Users. The restoration process shall take into consideration generator capabilities and operational constraints of the transmission network. All users shall be aware of the requisite steps to be taken during the following: -

a) Partial system blackout
b) Total system blackout
c) Synchronisation of system islands

During system restoration following a disturbance, emergency standards of frequency and voltage shall apply.

Users drawing load will identify non-essential components of their load for the purpose of switching them off during system contingencies to aid in system restoration. The non-essential loads can be switched on only when the system is restored as advised by the TSO. All Users shall pay special attention in carrying out the procedures so that secondary collapse due to undue haste or inappropriate loading is avoided. Despite the urgency of the situation, careful, prompt and complete logging of all operations and operational messages shall be ensured by all Users to facilitate subsequent investigation into the incident and the efficiency of the restoration process.

5.7 Data and Records Storage

TSO shall maintain a historical database of power and energy demand. This information is very useful as input to demand forecasting and for reconciliation and reporting.

5.7.1 Demand and Energy Data

The following historical data shall be maintained to facilitate System Studies:

a) Energy produced by source of energy
b) Energy sent out by source of energy
c) Energy at the Connection Points and at substaions
d) System maximum demand
e) Substations maximum demand
f) Substations demand at the time of the System Peak
g) Substations demand at the time of the System off peak

The data shall be captured on half hourly basis and an electronic copy shall be kept and hard copy may be produced on request.

5.7.2 Safety records

Legibly written Switching Logs, in chronological order, shall be maintained by both designated Senior Authorised Persons of TSO and Users for all operations and messages relating to safety co-ordination sent and received by them. All Switching Logs and safety documents issued for work on plant and / or equipment shall be retained for a period of not less than one year.

5.7.3 Fault Recording And Reporting

TSO shall produce reports for all faults on the TSO grid. Users whose equipment is faulted and impacts on the TSO grid must report the details of such a fault to TSO within 14 days. TSO shall record all relevant information pertaining to the fault.

Fault reports shall contain the following information:

a) Date and time of Fault
b) Location of Fault
c) Circuit Breaker(s) operations
d) Cause of Fault
e) Injuries to Persons and/or Damage to Plant
f) Load Interrupted and Duration of Interruption
g) Protection Operations
h) Any other relevant information

The fault reports for TSO grid related disturbances shall be made available to Users on request.

5.8 Safety Coordination

This section specifies safety requirements to be used by TSO and all Grid Users so as to maintain safety of personnel, plant and /or equipment.

5.8.1 Responsibility

TSO shall be the custodian of safety procedures and documents used when working on plant and / or equipment on the transmission grid and at all points of connection with the Users. TSO shall not impose these safety requirements for work outside the transmission grid and beyond the points of connection. Only Competent Persons authorised by TSO shall be permitted to carry out any work and network switching on the transmission grid and at the point of connection. The safety requirements are as captured in the LEWA Supply Rules.

5.8.2 Authorised Persons

A list of the Senior Authorised persons (names, designations and telephone numbers) for the TSO transmission grid and for Users at points of connection shall be circulated to TSO and all grid Users. The list must be updated promptly whenever any of the information changes.

5.8.3 Work On Plant and Equipment

Work must commence only after it has been made safe to work on through the following steps.

i. Opened (source of power removed).
ii. Isolated (physically disconnected form source of power).
iii. Safety tested
iv. Earthed (connected to the earth)
v. Safety documents issued

The designated Senior Authorised Person shall ensure that adequate safety precautions are established and maintained throughout the work. The equipment shall only be considered suitable for return to service when all safety documents have been cleared and isolation points normalized.

5.8.4 Accidents During Work

In the event of an accident during work on the TSO grid or at points of connection the following steps shall be taken:

a. Responsible Person stop work and attend to the injury if any.
b. Responsible Person shall notify Senior Authothorised Person, who will decide whether work should continue or not.
c. Senoir Authorized Person shall notify system Controller and Safety Officer
d. Senoir Authorized Person shall produce a preliminary report and notify TSO management, Grid Code Review Panel and LEWA within 5 days.
e. TSO shall constitute a committee for further investigation
f. Produce a detailed accident report.
g. Circulate report internally and to key people in the Users' systems.

5.9 Communications

Telecommunications are the basic infrastructure that makes remote operations of a system possible. It is, therefore, imperative that telecommunications be highly reliable and available.

TSO and Users shall advise each other of the telephone numbers to be used for operational purposes. TSO shall ensure that all operational lines are monitored for future replay should any disputes arise or as a tool in incident investigation.

5.10 Demand Control

Provisions of this section are to enable TSO to implement demand reduction or demand addition in a manner that ensures the continued balance between supply and demand.

TSO shall be responsible for issuing instructions to Users for dropping or connecting load under emergency or normal conditions.

5.10.1 Planned Demand Control

If the case of a supply demand mismatch is foreseen TSO will alert Users

drawing power from TSO grid in terms of the times and load quantum to be curtailed.

TSO shall consult the Users in producing a load shedding programme that shall be followed when there is planned load demand control. During emergency TSO may curtail load in a manner that does not strictly follow the agreed load shedding programme.

5.10.2 Emergency Automatic Demand Control

Emergency automatic demand control occurs when there is a sudden loss of generation substantially in excess of spare plant capacity. TSO in consultation with grid Users shall prepare the plan for automatic load shedding during the low frequency conditions.

During periods of low frequency conditions, generating stations shall assist through the following:

a. Endeavour to assist the system frequency to rise to 50 Hz, by increasing generation whenever possible.
b. Not disconnecting manually from the transmission system unless there is definite evidence that a complete failure of generation would otherwise result.

5.11 Power System Restoration After Blackout

TSO is required to direct and co-ordinate restoration efforts after blackouts. This can only be achieved safely and quickly by using a well - organised and systematic approach as specified in this Section.

It is incumbent on all grid Users authorised to carry out switching on the network to be thoroughly familiar with and observe the following restoration procedures:

a) TSO and the Grid Users are required to accurately assess the extent of the blackout and the status of plant and equipment , and from available information determine the best approach for restoring supply.

b) Critical loads shall receive priority.

c) TSO shall direct and co-ordinate system restoration with Users

and interconnected utilities in accordance with standing instructions and laid down procedures.

d) Generating Plant Operators shall direct and co-ordinate the start -up of generating machines to be ready for synchronising in accordance with local standing instructions and procedures.

e) Restoration work should be conducted in accordance with all applicable Operating Rules.

f) The respective Operators must ensure that an accurate and complete log is maintained for post event analsyis.

All switching operations on the TSO grid shall be in line with provisions ofthe TSO operating rules. During restorations, part(s) of the TSO grid may be deliberately isolated from the integrated network when such isolation would:

a) prevent a total grid collapse.
b) enable early restoration of power supply.
c) prevent imminent damage to equipment
d) be part of TSO approved under frequency/ islanding scheme

Complete synchronisation of integrated grid shall be restored, as soon as the conditions permit. TSO shall supervise the restoration process.

5.12 Network Switching

TSO needs to carry out network switching in order to implement maintenance outage programmes, connect new systems, facilitate system and / or protection tests, control voltage, load management and to respond to emergency and fault situations on the transmission network.

TSO shall inform Users, where practicable, of switching actions that may be likely to affect the operations of Users or security of supply to Users. In this regard TSO shall consult with Users in order to find out and take into consideration reasonable objections raised by the same.

Network switching may also occur automatically or without advance warning due to operation of protection equipment to clear or isolate faults deliberately to mitigate negative impact of faults on voltage and equipment loading.

SECTION 6

METERING CODE

6.1 Introduction

This Grid Code sets out a uniform policy in respect of electricity metering at boundaries between entities (Connection Points) so that the transfer of electrical energy is properly accounted for.

6.2 Objective

The objective of the Code is to define the minimum acceptable metering standards for the purpose of accountability, billing of electrical energy at the Connection Point as specified in the Connection Agreement.

The Code also specifies the requirement of calibration, testing and commissioning for metering equipment. The Code broadly indicates the technical features of various elements of the metering, security, meter reading and the procedure for the resolution of disputes.

6.3 Scope

The scope of this Code covers the practices that shall be employed and the practices that shall be provided for the measurement and recording of energy and demand.

6.4 Metering Equipment

The metering equipment at the Connection Point shall consist of some or all of the following:

(a) Instrument transformers;
(b) Lightning protection;
(c) Energy and demand meters and all associated accessories;
(d) Integrating pulse recorder(s) and time source; and
(e) Test interfaces to include test blocks for Users

6.5 Billing Meters

Billing meters shall be designed and installed so as to measure imports from generators and exports to Grid Users. As far as possible the billing meters shall be connected at the delivery point i.e., for energy exported from

generators to the Grid at the HV side of the generator transformer (step up transformer) and for energy imported from the Grid for station consumption on the HV side of the station transformer.

Billing meters for the imports/exports on inter-connectors shall be installed at the receiving/sending substation. The meters, however , must be configured to compensate for losses from/to the National Border.

Similarly, at the Connection Point with Grid Users, two meters shall be installed - One Main and the other Check.

The metering data shall have separate recording of the input and output Energy and Demand at each Connection Point. It shall include all quadrants in which Reactive Power flow is possible.

a)

6.6 Responsibility For Metering Installations

a) A Generating Company shall own all generation Main Metering and shall be responsible for ensuring that the metering equipment complies with the metering standards and requirements of this Code.
b) The Check Meter will be the responsibility of TSO.
c) All billing meters at the Connection Point shall be the responsibility of TSO. In this case, TSO shall own the Main Meter and Grid User the Check Meter.
d) All Interconnections shall be governed by SAPP Interconnection Rules.
e) Energy consumed by a Generating Plant and drawn from TSO Grid shall be measured by a billing meter . The Generating Company shall pay for this energy drawn through the station transformer from the grid. The metering shall be connected on the HV side of the station transformer and shall belong to TSO.
f) TSO shall be responsible to ensure that all points identified to be metering points have metering installations.
g) TSO shall recover its costs for metering installation through connection charges.
h) TSO shall be responsible to manage and collect metering information for the Connection Point.
i) Users connected or wanting to connect to the Grid shall providethe TSO with all information deemed necessary to enable performance of its metering duties.

6.7 Metering Equipment Standards

6.7.1 Voltage Transformers

a) The voltage transformers shall comply with the IEC 44 Standard or its equivalent national standard for metering, and should be of the 0.5 accuracy class. These voltage transformers shall be connected Wye-Wye with both star points grounded to a grounding grid of acceptable resistance and shall provide a four-wire secondary connection.
b) The voltage drop in each phase of the voltage transformer connections of the same accuracy and class shall not exceed 0.2 V. It shall be connected only to a billing meter with a burden that shall not affect the accuracy of measurement.

6.7.2 Current Transformers

a) The current transformers shall comprise three units for a three-phase set , each of which complies with the IEC 44 Standard or its quivalent national standard for metering, and is of 0.5 accuracy class. It is preferred that two (2) current transformer cores with corresponding number of secondary coils per phase be provided, one connected to the Main Meter and the other to the Check Meter.
b) The current transformer 's rated secondary current shall be either 1 or 5 amperes. The neutral conductor shall be effectively grounded at a single point . The current transformer shall be connected only to a billing meter with a burden that shall not affect the accuracy of measurement.

6.7.3 Meters

a) Meters shall be of the three-phase, three or four wire type,rated for the required site, comply with the appropriate IEC Standards or their equivalent national standards, for static watt -hour meter and other types of meters, and be of the accuracy class of 0.2 or equivalent . The meters shall measure and locally display at least the kW, kWh, kVAR, kVARh, and cumulative Demand; and shall have the features of time-of-use, maintenance records, and pulse output.
b) A cumulative record of the parameters measured shall be available on the meter . Bi-directional meters shall have two such records available. If combined Active Energy and Reactive Energy meters are provided, then a separate record shall be provided for each measured quantity and direction. The loss of auxiliary supply to the meter shall not erase these records.

c) For all metering installations, pulse output shall be provided for each measured quantity. The pulse output shall be from a three-wire terminal with pulse duration in the range from 40 to 80 milliseconds (preferably selectable) and with selective pulse frequency or rate.
d) The minimum pulse frequency shall comply with the IEC 44 Standard or its equivalent national standard, for the shortest integration period and the accuracy class of the meter.
e) Pulse output shall be galvanically isolated from the voltage/ current transformers being measured and from the auxiliary supply input terminals.
f) The insulation test voltage shall be 1000 VAC, 50 Hz and applied for one minute.

6.7.4 Integrating Pulse Recorders

a) Integrating Pulse Recorders shall be capable of recording integrated Demand periods adjustable between fifteen (15) minutes and sixty (60) minutes.
b) Each recorder shall be capable of electronic data transfer through dedicated telephone lines or TSO's communication channels or manual downloading of data on-site.
c) The integrating pulse recorders shall provide a record for reference at a future time. The record shall be suitable for reference for a period of at least one year after it was generated. The integrating pulse recorder shall be regularly interrogated and the record shall also be maintained at the recorder for two (2) complete billing periods between one (1) interrogation or sixty (60) days,whichever is longer.
d) The time reference used with the Demand recorder shall ensure that the Demand period accuracy of this integrating pulse recorder is with a time error of no more than +/- 1 second.
e) All billing meters shall record time, based on the Greenwich Mean Time(standard time).
f) The start of each demand period shall be within +/- 30 seconds of the standard time.
g) Reprogramming of integrating pulse recorders shall be done as soon as possible within one billing cycle if there is a time error.

6.8 System Monitoring

6.8.1 Instrument Transformer Testing

a) Test on the Instrument Transformers at the Connection Point , shall

be done by TSO and the concerned User during the Test and Commissioning stage and then at least once every five (5) years or as the need arises due to queries on accuracy. The tests shall be carried out as specified in this Section of the Grid Code or an agreed equivalent international standard.

b) An Instrument Transformer shall not be connected to a load beyond its rated burden and shall be operated at the optimum burden range to achieve maximum accuracy of the metering system. Burden Test shall be conducted during commissioning, re-installation or relocation or when requested by the User and/ or the TSO. Loading resistors for compensating low burdens may be allowed as long as accuracy level is sustained.

6.9. Meter Testing and Calibration

TSO and the User shall test and seal the meters at least once a year and recalibrate according to manufacturers' specification or replace such meters if found to be faulty.

6.9.1 Request for Test

a) A Grid User or TSO may request a test of the installed metering equipment if it has reason to believe that the performance of the Equipment is not within the accuracy limits set forth in clause 6.10 of this Grid Code . The test shall be done by the two concerned Users or an independent entity approved by both Users.

b) If the metering equipment fails the test, TSO shall pay for the cost of the test. If the meter Equipment passes the test, the party who requested the test shall pay for the test cost.

6.10.1 Maintenance of Metering Equipment

a) The metering equipment at the Connection Point shall be maintained by TSO. All test results, maintenance programs, and sealing records shall be kept for the life of the equipment for Users' reference.
b) TSO shall repair the metering system within two (2) days if a metering system malfunctions. TSO shall charge for the metering services provided.

6.10.2 Metering Equipment Security

TSO shall take all reasonable steps to prevent unauthorized interference with the equipment. TSO shall provide seals and other appropriate devices

to prevent unauthorized alteration on site settings and calibrations. The metering equipment cubicle shall be completely and securely locked and sealed, provided any register on equipment is visible and accessible. TSO shall also provide appropriate security against unauthorized access and against corruption of data in transmission.

6.11 Meter Reading and Metering Data

6.11.1 Integrating Pulse Metering Data

a) TSO shall download Integrating Pulse Metering data (the actual hourly data on generation and off-takes at each Connection Point) for billing and settlement purposes. Each User shall be provided full access to the data for his Connection Point.
b) The pulses from two or more meters may be combined into one Integrating Pulse Recorder provided all the requirements of this Section of the Grid Code are met.
c) The meter pulses that need to be integrated into the recorder are:

    i. Active Energy and Demand incoming and outgoing in the Grid;
    ii. Reactive Energy and Demand incoming and outgoing in the Grid

d) Provisions shall be made by TSO to permit on-site as well as remote interrogation of the Integrating Pulse Recorder.

6.11.2 Running Total of Active Energy and Power

At input / output connections, the Active Energy and Active Power metering shall provide the running total of the Energy. Combined meters which measure both the Active Energy and Active Power input into and output from the Grid shall have the running totals available for each measured quantity, each direction, and each quadrant or combination of quadrants.

6.11.3 Running Total of Reactive Energy and Power

At input / output connections, the Reactive Energy and Reactive Power metering shall provide the running totals of the Energy. Combined meters which measure both the Reactive Energy and Reactive Power input into and output from the Grid shall have the running totals available for each measured quantity, each direction, and each quadrant or combination

of quadrants.

6.11.4 Billing and Settlement Procedure

The billing and settlement procedures shall be as outlined in Service Levels Agreements and/or Power Purchase and Power Supply Agreements.

6.12 Settlement Audit Procedure

6.12.1 Right to Request Settlement Audit

The User shall have the right to request an audit of the settlement data related to its account and the right to choose an independent third party qualified to perform the audit. TSO, Generating Company and Grid Users shall cooperate in the auditing process.

6.12.2 Allocation of Audit Cost

The external auditor has to be approved by all concerned Users. The requesting party is responsible for all outside auditor costs.

6.12.3 Audit Results

The audit results shall be issued to the billing party who shall issue a response to the audit report.

6.12.4 Audit Appeals

If User disagrees with the billing party's response to the audit, that response may be referred to LEWA.

6.13 Confidentiality

Metering data and passwords are confidential information and shall be treated as such at all times.

SECTION 7

PROTECTION CODE

7.1 Introduction

This Section specifies the minimum protection requirements as well as typical settings, to ensure adequate performance of the power network as experienced by the Users. TSO shall at all times install and maintain protection installations that comply with the principles and specifications of this Section.

7.2 Objective

The objective of the Protection Code is to define minimum protection requirements for the Grid. This is done in order to:

a) Limit safety hazards to the power utility personnel and public.
b) Minimise damage to Equipment
c) Prevent damage to healthy equipment that conducts fault current during faults
d) Restore supply over the remaining healthy Grid
e) Sustain stability and integrity of a System
f) Ensure agreed power quality to Users

7.3 General Principles

Protection schemes are generally divided into:

a) Equipment protection and
b) System protection.

The main functions of Equipment protection are to selectively and rapidly detect a fault and disconnect a faulty circuit . The main function of System protection is to respond to a System condition as opposed to a System fault e.g. under frequency, voltage slide, out of step or subsynchronous resonance and undertake appropriate automatic actions to maintain power network integrity.

The protection functions are considered adequate when the protection relays perform correctly in terms of:

a) Dependability
b) Security
c)Speed of operation
d) Selectivity
e) Sensitivity

All Grid Users shall ensure correct and appropriate settings of protection to achieve effective removal of faulty equipment within the clearance time specified in Section 7.6 of this Grid Code. Protection settings at the Connection Point shall not be altered, or protection bypassed and/or disconnected without consultation and agreement of TSO and the Grid User. In the case where protection is bypassed and/or disconnected, by agreement, then the cause must be rectified and the protection restored to normal condition within one (1) day. If agreement has not been reached the electrical equipment will be removed from service forthwith.

7.4 Protection Coordination at the Connection Point

TSO shall be responsible for co-ordination of protection at the Connection Point and shall investigate any mal-function of protection or other unsatisfactory protection issues at the Connection Point. Grid Users shall take action within one (1) day to correct any protection mal-function.

7.5 Testing of Protection Equipment

TSO shall conduct periodic tests of equipment and systems to ensure they are performing to the designed specifications. Periodic tests must be performed within a period of two years. Each Grid User is responsible for tests on own equipment and test results shall be submitted to TSO on request. The tests are to be done as per the test procedures detailed under this Section of the Grid Code and as specified from time to time by TSO.

7.6 Fault Clearance Times

From a stability consideration the maximum fault clearance times for faults on any Grid Users' systems, or any faults on the Grid itself, are as follows:

Allowable Maximum Clearance Times:

132 kV 190 milliseconds
88 kV 190 milliseconds
66 kV 190 milliseconds
33 kV 240 milliseconds

7.7 Generator Protection Requirements

All Generating Units and all associated electrical equipment of the Generator connected to the Grid shall be protected by adequate protection so that the Grid does not suffer due to any disturbance originating from the Generating Unit. The minimum protection for the generators shall constitute the following:

a) Overcurrent and Earth Fault
b) Differential Protection
c) Reverse power protection
d) Overvoltage protection
e) Negative phase sequence
f) Field failure
g) Overspeed protection
h) Under and over frequency

7.8 Transmission Line Protection Requirements

Every Transmission line taking off from a Generating Plant or a sub-station shall have Main and Back Up protection. TSO shall notify Grid Users of any changes in its policy on protection from time to time. Protection requirements for transmission differ slightly for short and long lines.

7.8.1 Transmission Line Protection Design Standard

On long lines the main protection shall be Distance Protection and on short lines it shall be Differential Protection. Transmission lines shall be equipped with adequate protection systems, which include one or two discreet Distance Protection Relays (Main1 and Main 2). Where Main 1 and Main 2 protection systems are installed and where practicable, these shall be designed to operate independently of the other. The relays should be connected to separate measuring transformers and auxiliary supplies fused separately.

The minimum requirement for the protection of the protected line is three forward zones. Zone 1 should normally be 80 % of the protected line and zone 2 and zone 3 should be 120 % and 150 % of the protected line respectively. and should have 15 % reverse each on the protected line.

The Distance Protection should also operate on different schemes (permissive over-reach and permissive under-reach). Directional Earth Fault protection shall be incorporated in the Distance Protection Relays or installed as a separate relay to provide more sensitive protection against high impedance Earth Faults. Back up over-current and Earth Fault protection shall be installed.

7.8.2 Automatic Re-closing (ARC) On Transmission Lines

The most important consideration in the application of automatic reclosing (ARC) on transmission lines is the maintenance of system stability and synchronism. Automatic reclosing is initiated following Zone1operation of the Distance Protection Relay and subsequent tripping of the circuit breaker for a fault on the line.

ARC sequence will comprise a single phase High Speed Auto Reclosing (HSAR) followed by three phase Delayed Auto Reclosing (DAR) if necessary. Note that for three phase fault only the delayed auto reclosing should be initiated

7.8.3 Power Swing Blocking

Power swings are variations in power flow which occur when the voltage of generators at different points of the power system slip relative to each other to cater for changes of load magnitude and direction or as a result of faults and their subsequent clearance. The result of a power swing may cause the impedance presented to a distance relay to move into the relay-operating characteristic. In the case of a transient power swing, it is important that the distance relay should not trip and should allow the power system to return to a stable condition.

New and replacement distance relays on the transmission system shall have a power swing-blocking feature available. TSO will ensure that this feature is enabled for the Transmission lines.

7.11 Transformer Protection Requirements:

All power transformers in a Generating Plant and Transmission System shall be protected by differential and Restricted Earth Fault (REF) Relays. In addition there shall be back up time lag Over Current and Earth Fault protection. For transformers operating in parallel , Back up Over Current and Earth Fault protection shall have a directional feature at the Connection Point. The Over Current Relays should incorporate a high set instantaneous element. In addition to electrical protection, gas operated relays, winding temperature protection and oil Temperature protection shall be provided.

7.12 Sub- Station Bus Bar Protection

All Users shall provide adequate bus zone protection for substation bus bars in all Transmission substations.

7.13 Teleprotection Requirements

7.13.1 Introduction

Teleprotection is used in the TSO network as part of the overall protection schemes associated with High Voltage networks in order to achieve fast and selective fault clearances independent of the fault location and system Conditions.

7.13.2Teleprotection Schemes

i. Direct Transfer Trip (DTT)

Direct Transfer tripping shall be applied on all substations and transmission lines with Distance Protection schemes at both ends, for busbar protection scheme and line differential protection. DTT shall be set to operate for Distance Protection zone 1 operation. Receipt of the signal at the remote end initiates the tripping immediately at this end.

ii. Permissive Under Reach Transfer Trip (PUTT)

PUTT shall be set to operate for under reaching Zone 1 elements of the Distance Protection Relay operation, trip the associated breaker and send an inter trip signal to the remote end. Receipt of the carrier signal and the operation of the zone 2 elements cause an instantaneous trip of the breaker at this end.

iii. Permissive Over Reach Transfer Trip (POTT)

POTT shall be set to operate for the over reaching zone 2 elements of the Distance Protection, trip the associated breaker and send an inter trip signal via the teleprotection relay to the remote end. Receipt of the carrier signal and the operation of the over reaching Zone 2 elements at this end causes an instantaneous trip of the breaker at this end.

iv. Blocking Schemes

Blocking schemes shall be applied where the Distance Protection Relay zone 3 reverse looking elements are used to block instantaneous tripping of the remote relay for Zone 2 faults external to the protected line section. In this scheme, signaling is only initiated for external faults and signaling transmission takes place over healthy line section.

7.14 Overvoltage Protection

Overvoltages in the System are caused by lightning surges, switching surges and sudden load throw off. Over voltage surges cause possible failure of

insulation on transformers, motors and other related electrical equipment. They also cause possible flashovers on highly stressed points external or internal of to equipment.

7.14.1 Protection against Lightning Over voltages.

This shall be achieved through the following;

i. Rod Gaps

These shall be applied across insulator string or bushing insulators. The gap shall be set to allow the breakdown of the insulation medium at voltages above 140% of nominal as specified in the TSO' s Parameter Guidelines for Protection Test.

ii. Horn Gaps

These shall be applied above overhead lines or substations to provide effective protection against direct strike on line conductors, towers and substation equipment. All sub-transmission and transmission overhead lines shall be provided with Horn Gaps. Horn Gaps shall be set to provide effective protection against direct strikes on line conductors, towers and substation equipment as specified by TSO.

iii. Lightning Masts

These shall be applied above buildings to protect them against direct lightning strikes. All substation buildings shall be provided with lightning masts for protection against direct lightning strikes. The lightning masts shall be designed as specified by TSO.

iv. Surge Arrestors

These shall be applied on lines terminating at the substations and on the transformer terminals so that they divert over voltages to earth without causing short circuits. The surge arrestors shall be as specified by TSO.

v. Shield Wire

Overhead power lines shall be equipped with a shield wire (ground conductor or overhead earth wire). A shield wire is a conductor that is usually grounded (earthed) at the top of the supporting structure to minimize the likelihood of direct lightning strikes to the phase conductors. Shield wires on transmission lines shall include optical fibers (optical ground wires (OPGW)), used for communication and

control of the power system.

7.15 Protection Against Switching Surges at the Connection Point

a) Shunt reactors and /or pre-closing resistors on circuit breakers shall be installed to protect against switching surges.
b) All circuits at the Connection Point shall be equipped with surge suppressors and arrestors to limit over voltages.

7.16 Protection of Compensating Equipment

7.16.1 Protection of Reactors

All reactors shall be protected at the minimum, by Over Current and Earth Fault Protection, Differential Protection, Restricted Earth Fault Protection, Gas operated and temperature relays.

7.16.2 Protection of Capacitors

All Capacitors shall be protected by a minimum of Over Current and Earth Fault Relays.

7.16.3 Protection of Static Var Compensators

All Static Var Compensators shall be protected by Over Current and Earth Fault Relays.

7.17 Under frequency Load Shedding

TSO shall employ an automatic Load Shedding scheme when frequency falls to 48.5 HZ and below.

7.18 Safety Protection Requirements

7.18.1 Fire Protection

a) All energised electrical equipment is capable of causing fire if proper usage and handling procedures are not adhered to.

b) All TSO substations and Connection Points should be equipped with appropriate electrical fire extinguishers located at strategic points at each substation. These shall be tested on annual basis.

c) The transformers in the switchyard shall be provided with barrier walls. The walls shall be covered with refractory bricks. The wall shall prevent the spreading of fire from one transformer to another.

d) Fireguards should be created and maintained around the perimeter of every substation and Connection Point.

e) All chemicals capable of causing fire should be stored at sites away from electrical plant in every substation and Connection Point.

f) Adequate precautions shall be taken and protection shall be provided against fire hazards to all indoor equipment.

7.18.2 Personnel Protection

All personnel that have to carry out any works at the Connection Point or TSO Substation shall abide by the LEWA Safety Rules and any other Safety requirements that shall be put in place by TSO from time to time. As a measure to protect personnel against electrical hazards the following shall be observed at all times.

i. Visitors

All visitors to the Connection Point or TSO substation shall obtain the relevant authority to enter and sign the Visitors Live Enclosure Permit before entering.

7.18.4 Equipment Switching Personnel

All switching in the Connection Point or TSO substation shall be carried out by a TSO Senior Authorized Person under the recorded Instruction of a TSO Controller.

7.18.5 Personnel Carrying out Works

All works at the Connection Point or any part of the TSO Network shall be carried out under approved TSO Safety Documents.

7.19 Earthing Requirements For Substations

7.19.1 Earthing Systems

i. All substations Earthing Systems should have Earth Resistance lower than 1 Ohm for effective discharge of lightning or overvoltages to earth.

ii. The current carrying paths of an Earthing System should have enough

capacity to deal with maximum fault current

iii. Earthing Mats shall be provided below ground level and earth electrodes shall be driven into ground at several points and shall be connected to the Earthing Mat .

iv. All structures, transformer tanks, breakers, equipment panels shall be connected to this mat by copper strips.

7.19.2 Periodic Checks on Earthing Systems

I. Buried elements of the earthing system should be checked for condition at random points as and when necessary but not exceeding a period of five (5) years.
II. Circuit continuity should be checked between earthing devices and earthed elements. Open circuits and high resistance connections should be investigated and rectified when regular maintenance is being carried out.
III. Earthing resistance should be measured and if more than 0.5 Ohms, it should be reduced by the addition of resistance reducing compounds.

SECTION 8

INFORMATION EXCHANGE CODE

8.1 Introduction

The Information Exchange Code defines the reciprocal obligations of Users with regard to the provision of information for the implementation of the Grid Code. The information requirements are necessary to ensure non-discriminatory access to the Transmission System and the safe, reliable provision of transmission services.

The information requirements are divided into planning information, operational information and post-dispatch information.

Information criteria specified in the Information Exchange Code are supplementary to the other codes within the Grid Code.

8.2 Information Exchange Interface

The Users shall identify the following for each type of information exchange:

a) The contact details of the person responsible for provision of the information.
b) The contact details of User's persons requesting the information.
c) The purpose for which the information is required.

8.3 Confidentiality of Information

a) Information exchanged between Users governed by this code shall be confidential.
b) Confidential information shall not be transferred to a third party without the written consent of the information owner.
c) Users shall observe the proprietary rights of third party Users for the purposes of this code.
d) Access to confidential information within the organisations of Users shall be provided as reasonably required.
e) Users receiving information shall use the information only for the purpose for which it was supplied.
f) The information owner may request the receiver of information to enter into a confidentiality agreement before confidential information is provided. Such agreement shall be signed for by both parties.
g) The Users shall take all reasonable measures to control unauthorized access to confidential information and to ensure secure information

exchange.

h) Users shall report any leak of information that is governed by a confidentiality agreement within one (1) day after they become aware of the leak, and shall provide the information owner with all reasonable assistance to ensure its recovery or destruction (as deemed appropriate by the information owner).

8.4 Telephone/Fax

The Grid User and TSO shall be responsible for the provision and maintenance of no less than one telephone and one fax unit that shall be reserved for operational purposes only, and shall be continuously attended to and answered without undue delay.

TSO shall use a voice recorder for historical recording of all operational voice communication with Grid Users. These records shall be available for at least one (1) year. TSO shall make the voice records of an identified incident in dispute available within two (2) days after such a request from the Grid User and/or LEWA.

8.5 Electronic Mail

The exchange of archived data shall preferably be carried out electronically.

LEWA will work with the government, TSO, and stakeholders to maintain and enforce Cyber Security standards.

8.6 System Planning Information

8.6.1 Grid Users shall provide such information as and when requested by TSO for the purposes of planning and developing the Transmission System. The Users shall submit the information to TSO without undue delay. Such information may be required so that TSO can plan and develop the Transmission System, monitor current and future power system adequacy and performance , and fulfill its statutory or regulatory obligations.

8.6.2 Grid Users shall submit to TSO the relevant information as specified by TSO from time to time.

8.6.3 TSO may request additional information as and when required.

8.6.4 TSO shall keep an updated technical database of the System for purposes of modelling and studying the behavior of the Transmission System. TSO shall provide Grid Users or potential Grid Users, upon request,

with information that they require to plan and design their own networks/ installations or comply with their obligations in terms of the Grid Code.

8.6.6 TSO shall make available all the relevant information related to network planning as described in the Grid Connection Code.

8.6.7 Users shall, upon request to upgrade an existing connection or when applying for a new connection provide TSO with information as shown in Table 8.6.

Table 8.6 System Planning Requirements for Users

Commissioning	Projected or target commissioning test date
Operating	Target operational or on-line date
Reliability/ type of connection requested	Number of connecting circuits, e.g. one or two feeders, or firm/non-firm supply required Upgrades: name of existing point of supply to be upgraded and supply voltage
Location	New connections: provide a 1:50 000 or other agreed scale location map, with the location of the facility clearly marked. In addition, co-ordinates of the point of connection to be specified
Site plan	Provide a plan of the site (1:200 or 1:500) of the proposed facility, with the proposed point of supply, and where applicable, the transmission line route from the facility boundary to the point of supply, clearly marked
Electrical single-line diagram	Provide an electrical single-line diagram of the Grid Users intake substation and to provide an accurate record of the layout of circuits, numbering and nomenclature of equipment and plant.

8.6.8 TSO may estimate any System planning information not provided by the Grid User. TSO shall take all reasonable steps to reach agreement with the Grid User on estimated data items. TSO shall indicate to the Grid User any data items that have been estimated. The obligation to ensure the correctness of data remains with the Grid User.

8.6.9 Generating Company shall submit to TSO all the maintenance planning information detailed in Section 5 of this Grid Code with regard to each unit at each power station.

8.7 Operational Information

8.7.1 Pre- commissioning Studies

Users shall meet all system planning information requirements before the commissioning test date. (These will include confirming any estimated values assumed for planning purposes or, where practical, replacing them with validated actual values and with updated estimates for the future.)

8.7.2 Commissioning and Notification

(a) Records of commissioning shall be maintained for reference by the User for the operational life of the plant and shall be made available, within seven (7) days, to TSO upon notification of such request.

(b) The User shall communicate changes made during an outage to commissioned equipment, to TSO before the equipment is returned to service. TSO shall keep commissioning records of operational data for the operational life of the plant connected to the Transmission System.

8.7.3 General Information Acquisition

i. Supervisory Control and Data Acquisition (SCADA)

The information exchange shall support data from the SCADA system. The System Operator shall be able to monitor the state of the power system using the data from the remote terminal units (RTU).

The SCADA system shall be used for storage, display and processing of operational real time data. All Grid Users and Generating Companies shall make available outputs of their respective operational equipment to the data acquisition system or as specified in the connection agreement.

The data collection, storage, monitoring and display centre for TSO SCADA data shall be the National Control Centre.

ii.Generation Operational SCADA Data

A Generating Company shall provide operational information for both real time and recording purposes in relation to each Generating Unit at each Generating Plant in respect of indications and measurands as follows:

i. Energy in MWh
ii. Voltage
iii. Frequency
iv. Active Power in MW
v. Reactive Power in MVAr
vi. Circuit breaker status
vii. Any other additional data as specified in the connection agreement.

iii. **Transmission System Operational SCADA Data**

TSO and the Grid User shall specify the data characteristics for monitoring electrical supply and load characteristics at each sub-station and Connection Point. The data shall be both historic and real time in relation to each feeder, transformer and compensation device in respect of indications and measurandsas follows:

i. Energy in MWh
ii. Voltage
iii. Frequency
iv. Active Power in MW
v. Reactive Power in MVAr
vi. Circuit breaker status
vii. Any other additional data as specified in the connection agreement.

iv. Process Signals Interface to RTU

a) The interface of the process signals to RTU shall be as specified by TSO. The provision and maintenance of the wiring and signaling from the Grid Users plant and equipment to the interface cable to Main Distribution Frame (MDF) shall be the responsibility of the Grid User.

b) Measurands and indications to be supplied by Grid Users to TSO shall be in the formats as specified by TSO or as agreed between TSO and User. Where the required signals become unavailable or do not comply with applicable standards for reasons within the control of the provider of the information, such participant shall report and restore or correct the signals and/or indications as agreed by the two Users.

c) TSO shall notify the Grid User of additional measurands and/or indications in relation to a Grid User plant and equipment that are needed to meet a Transmission System requirements. The costs related to the participants modifications for the additional measurands and/or indications shall be for the account of the providing Grid User.

d) Within seven (7) days on receipt of such notification from TSO the Grid User shall ensure that such measurands and/or indications are made available at the RTU.

e) TSO and the Grid User shall agree on the timeous provision of operational data items as per the relevant Power Purchase Agreement and/or Power Supply Agreement.

f) TSO and Grid User shall jointly verify all measurandsand/or indications for functionality and accuracy once every three (3) years, so as to achieve overall accuracy of operational measurandswithin the limits agreed.

g) The data formats to be used and the fields of information to be supplied to TSO by the Grid Users shall be as per the Power Purchase Agreements.

h) TSO shall provide periodic feedback to Grid User regarding the status of equipment and systems installed at the Connetcion Point. The feedback shall include, but not be limited to, results from tests, condition monitoring, inspections, audits,failure trends and calibration. The frequency of the feedback shall be determined in the operating agreement/service level agreement.

8.8 Unit Scheduling

8.8.1Declared Available Capacity

A Generating Company shall complete and submit to TSO the Declared Available Capacity for each generating unit at a period specified by the Power Purchase Agreement. All scheduled and other outages which prevent some or all of the Dependable Capacity of each unit from being available for dispatch shall be specified. Should the Declared Available Capacity be less than the Dependable Capacity for any generating unit due to a reason other than Scheduled Outage, the Generating Company shall explain the reason for the reduction and the action planned to restore the unit.

8.8.2 Statement of Reduction and Re- establishment of Declared Available Capacity

a) Should a Generating Company become aware of a change in status of any Generating Unit following the submission of the Declared Available Capacity it shall make this status change known immediately to TSO by telephone, followed by written confirmation to be sent to TSO within one hour. A Generating Company shall confirm the reduction in Declared Available Capacity, the reason for the reduction, the action planned to restore the Declared Available Capacity to the Dependable Capacity level , and the estimated time required for such restoration.
b) Once the Declared Available Capacity can be increased over the Dependable Capacity, this change in status shall immediately be relayed to TSO by telephone communication, followed by written confirmation to be sent to TSO within one hour. TSO may then dispatch the Generating Unit at the Declared Available Capacity level.

8.8.3 Scheduled Capacity Requirement

a) TSO will notify a Generating Company of its Scheduled Capacity requirements for a plant for each hour of the day and a Generating Company will confirm acceptance and schedule. TSO will then dispatch the plant to the Scheduled Capacity as agreed by the two Users.
b) Should TSO require changing the Scheduled Capacity level of the plant, it shall notify a Generating Company of all changes through telephone communication, followed by sending a revised schedule to a Generating Company within one hour. A Generating Company will confirm acceptance and schedule. TSO will dispatch the plant to the revised Scheduled Capacity requirements as notified by the telephone Communication of the revised schedule.

8.9 Data Storage and Archiving

The obligation for data storage and archiving shall lie with the information owner.

8.9.1. The systems that store the data and/or information to be used by Users shall be of their own choice and for their own cost.

8.9.2. All the systems must be able to be audited by LEWA.

8.9.3 The systems must provide for clear and accessible audit trails on all relevant operational transactions. All requests for an audit of a system shall be made to the User thirty (30) days prior to the audit.

8.9.4 The information owner shall keep hard copies for a period of at least five (5) years commencing from the date the information was created.

8.9.5 Users shall ensure reasonable security against unauthorised access, use and loss of information (i.e. have a backup strategy) for the systems that contain the information.

8.9.6 Users shall store planning information that is kept electronically for at least five (5) years or for the life of the plant or equipment concerned, whichever is the longer.

8.9.7 TSO shall archive operational information, in a historical repository sized for three (3) years data. This data includes transmission time- tagged status information, change of state alarms, and event messages, hourly scheduling and energy accounting information and operator entered data and actions.

8.9.8 An audit trail of all changes made to archived data should be maintained. This audit trail shall identify every change made, and the time and date of the change. The audit trail shall include both before and after values of all content and structure changes.

8.10 File Transfers

The format of the files used for data transfer and transfer media shall be defined by the sender and receiver of the information. The users shall keep the agreed number of files for backup purposes so as to enable the recovery of information in the case of communication failures.

8.11 Performance Data

8.11.1 Generator Performance Data

a) A Generating Company shall provide TSO with monthly performance indicators for each unit at each power station in respect of availability

and reliability as determined from time to time by TSO.

b) A Generating Company shall report significant events, such as catastrophic failures, to the LEWA within one (1) week of occurrence of such event.

TABLE 8.7.2: Testing of Under- Frequency Load Shedding Relays

Date: Substaion: Fed from transmission (directly or indirectly):				
	Activating frequency		Timer setting	
	Required	As tested	Required	As tested
Stage 1				
Stage 2				
Stage 3				
Stage 4				
	Feeders selected (required)		Feeders selected (as tested)	
Stage 1				
Stage 2				
Stage 3				
Stage 4				

SECTION 9

RENEWABLE POWER PLANT CODE

9.1 Introduction

This Renewable Power Plant Code was developed to address an issue with wind and solar photovoltaic power plants. However, it applies to conventional generation as well as wind and solar photovoltaic power plants.

Conventional generation typically provides the capability to withstand disturbances on the network which result in temporarily depressed voltages. The rotating masses of conventional synchronous machines contribute fundamentally to frequency stability and control in the system. Regulation of rotational speed through governor action controls frequency while inertia of the rotational masses of synchronous machines acts to limit the rate of change of frequency in the event of a disturbance.

This was not the case at the outset of the modern development of wind power plants, which began with small units that were connected to distribution systems. Standards or codes were applied to such generators with a view to ensuring that they would not degrade system performance. It was expected that they would disconnect in the event of any disturbance (both for distribution network safety and to protect the wind power plant). As wind generation developed to the point where it would form a significant part of the total generation in a system or region, it became clear that a higher standard of performance would be required, similar to that which conventional power generation typically achieves. This Renewable Power Plant (RPP) Code is designed to provide the necessary higher standard of performance.

In the most common types of wind turbines being deployed today, namely doubly fed induction generators and full converter based machines, the rotational masses are decoupled from system frequency through the use of power electronics. Solar photovoltaic generation has no inertia to begin with and thus creates issues similar to wind generation, and its penetration has also been increasing rapidly. Significant deployment of these technologies can decrease total inertia on the system, thus increasing the need for frequency regulation but reducing the total regulation capability available. If system stability is not to be degraded by deployment of these technologies, the inertia and frequency control capability of the conventional machines which are displaced must be replaced.

Other renewable energy technologies typically have characteristics similar to conventional generation and are less problematic for system stability.

The capability to withstand disturbances on the network which result in temporarily depressed voltages is critical in maintaining power system stability and in preventing exacerbation of disturbances leading to the risk of cascading outages. It is in this area that more stringent requirements than previously for wind power (especially) and solar photovoltaic have been applied.

This RPP Code sets out the requirements for wind and solar photovoltaic renewable power plants so that they will be able to contribute to the stability of the Lesotho Transmission System.

9.2 Objective

The primary objective of this Renewable Power Plant Code is to specify minimum grid connection technical and design requirements for wind and solar photovoltaic Renewable Power Plants (RPPs) connected to or seeking connection to the Lesotho Transmission System.

9.3 Scope

The requirements in this RPP Code shall apply to all wind and solar photovoltaic RPPs with a design capacity of 5 MVA or larger connected or seeking connection to the Lesotho Transmission System, the Lesotho System Operator, and prospective electrical Network Service Providers.

This RPP Code shall, at minimum, apply to the following RPP technologies:

- Wind
- Solar Photovoltaic

9.4 Fault Ride-through Requirements

Fault ride-through refers to the ability of a Generator to remain connected during a system voltage disturbance.

Four main characteristics typically provide the requirements for RPPs in the event of a voltage disturbance:

- Conditions for which the turbines must remain connected
- *Active Power* provision during fault
- Voltage support requirements during the disturbance
- Restoration of *Active Power* after the fault has been cleared

Each is discussed in more detail below.

9.4.1 Remain Connected Voltage Conditions

A wind or solar photovoltaic RPP shall remain connected to the Lesotho Transmission System for voltage disturbances on any or all phases, where the system phase voltage measured at the HV terminals of the connection transformer remains above a specified level for a specified length of time.

The remain connected requirements take the form of a voltage vs. time profile which dictates the level of voltage drop or increase that an RPP must be capable of withstanding along with the time for which the voltage drop or increase should be endured.

Figure RPPC-1 shows the combinations of voltages and time that the RPP shall be able to endure.

Area A shows that the RPP shall be able to operate continuously between 0.9 p.u. and 1.1 p.u. In Area A the RPP shall stay connected to the network and uphold normal production.

Area B is the area between the Lower Bound and the bottom of the continuous operating range, at 0.9 p.u. In Area B the RPP shall stay connected to the network. Figure RPPC-1 shows that the RPP shall be able to withstand voltage drops to zero, measured at the Connection Point, for a minimum period of 0.15 seconds without disconnecting. Less severe voltage drops increase the length of time they must be endured. Just below 0.85 p.u. the voltage drop shall be endured for nearly two seconds. At 0.85 p.u. the voltage drop shall be endured a minimum of three seconds.

Area D is the area between the Upper Bound and the top of the continuous operating range, at 1.1 p.u. In Area D the RPP shall stay connected to the network. Figure 1 shows that the RPP shall be able to withstand voltage increases to 1.2 p.u. for at least two seconds.

Area C is the area outside the Lower Bound and below the continuous operating range, at 0.9 p.u. In Area C disconnecting the RPP is allowed.

Area E is the area above the Upper Bound and above the continuous operating range, at 1.1 p.u. In Area E disconnecting the RPP is allowed.

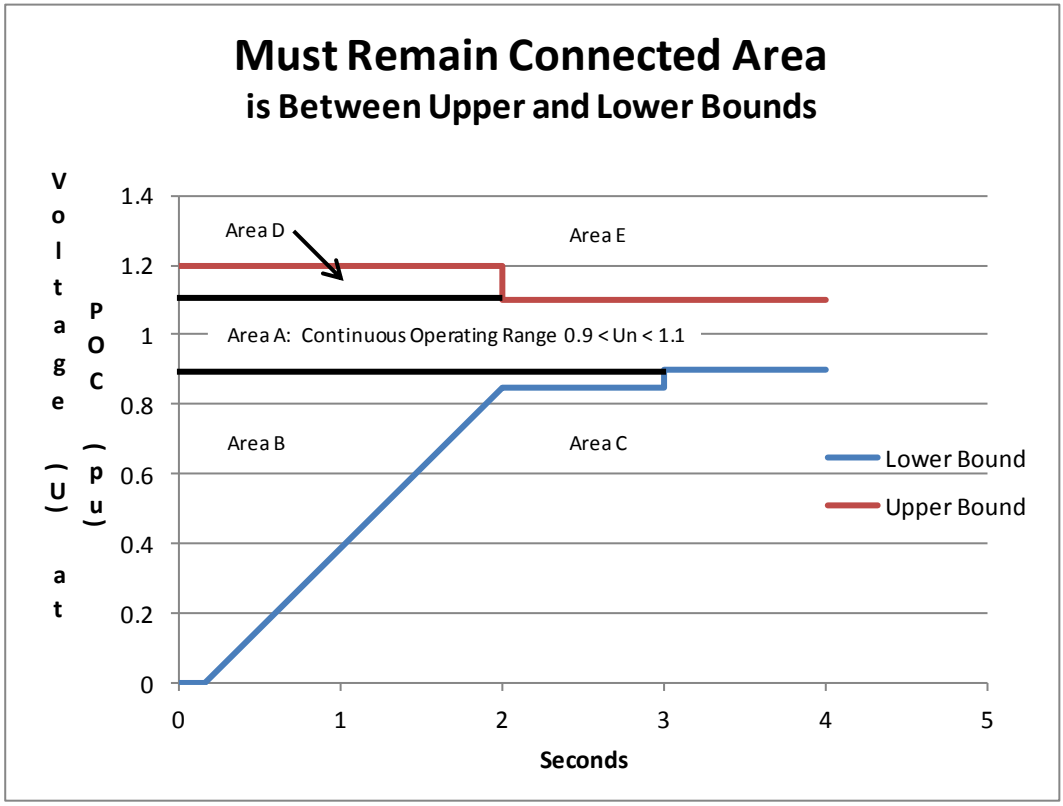


Figure RPPC-1 Voltage Must Remain Connected Area

9.4.2 Active Power Provision During Fault

During a voltage dip the controllable RPP shall provide Active Power in proportion to retained voltage and maximise reactive current to the Lesotho Transmission System without exceeding its declared limits.

9.4.3 Reactive Current Flows During Fault

The maximisation of reactive current during a fault shall continue for at least 600 ms or until the voltage recovers to within the normal operational range of the Lesotho Transmission System, whichever is the sooner.

9.4.4Active Power Recovery After Fault

The controllable RPP shall provide at least 90% of its maximum available Active Power as quickly as possible and in any event within one second of the voltage recovering to the normal operating range.

9.5 Active Power Control

The RPP control system shall be capable of operating the RPP at a reduced level if the Active Power output has been restricted by the TSO. The RPP control system shall be capable of receiving an on-line Active Power Control Set-point sent by the TSOand shall commence implementation of the setpoint within 10 seconds of receipt of the signal from the TSO. The rate of change of output to achieve the Active Power

Control Set-point should be no less than the maximum ramp rate settings of the RPP control system, as advised by the TSO.

9.6Ramp Rates

The RPP control system shall be capable of controlling the ramp rate of its Active Power output with a maximum MW per minute ramp rate set by the TSO. There shall be two maximum ramp rate settings. The first ramp rate setting shall apply to the MW ramp rate averaged over one (1) minute. The second ramp rate setting shall apply to the MW per minute ramp rate averaged over ten (10) minutes. These ramp rate settings shall be applicable for all ranges of operation including start up, normal operation and shut down. It is recognised that falling wind speed or frequency response may cause either of the maximum ramp rate settings to be exceeded.

It shall be possible to vary each of these two maximum ramp rate settings independently over a range between one (1) and thirty (30) MW per minute. The RPP control system shall have the capability to set the ramp rate in MW per minute averaged over both one (1) and ten (10) minutes.

The RPP operator and the TSO shall agree a procedure for setting and changing the ramp rate control.

9.7Rate of Change of Frequency Range

The requirements of Section 5 for remaining connected during a frequency disturbance apply when the rate of change of frequency is within certain limits. Outside these limits, the unit is not obliged to remain connected. RRPs shall remain connected to the Lesotho Transmission System during rate of change of frequency of values up to and including 1.0 Hz per second.

9.8 Voltage and Frequency for Synchronization

RPPs shall only be allowed to connect to the Lesotho Transmission System, at the earliest, 3 seconds after the voltage at the Connection Point is within ±5% around the nominal voltage, and the frequency in the Lesotho Transmission System is within the range of 49.0 Hz and 50.2 Hz, or otherwise as agreed with the TSO.

9.9 High Wind Curtailments

It shall be possible to continuously downward regulate the Active Power supplied by the RPP to an arbitrary value in the interval from 100% to at least 40% of the rated power. When downward regulation is performed, the shutting-down of individual Wind Turbine Generator systems is allowed so that the load characteristic is followed as well as possible.

The wind power Plant shall stay connected to the Lesotho Transmission System at average wind speeds below a predefined cut-out wind speed. The cut-out wind speed shall as a minimum be 25 m/s, based on the wind speed measured as an average value over a 10-minute period. To prevent instability in the Lesotho Transmission System, the wind power Plant shall be equipped with an automatic downward regulation function making it possible to avoid a temporary interruption of the Active Power production at wind speeds close to the cut-out wind speed.

Downward regulation shall be performed as continuous or discrete regulation. Discrete regulation shall have a step size of maximum 25% of the rated power. When downward regulation is being performed, the shutting down of individual Wind Turbine Generator systems is allowed. The downward regulation band shall be agreed with the Network Service Provider upon commissioning of the wind power Plant.

9.10 System Reserve Requirements

Increasing penetration of wind and photovoltaic generation, and to a limited extent other RPPs, can increase the need for various kinds of reserves. The variability of their output requires higher levels of both planning and operating reserves to offset the greater chance of being or going off-line when needed. They also contribute little or no inertia to the system, increasing the need for frequency regulation, which may lead to a need for higher levels of spinning reserve. These factors shall be taken into account in establishing both planning and operating reserve requirements.

9.11 Renewable Power Plant Hourly MW Production Forecast

Each Renewable Power Plant shall have the capability to produce and submit to the TSO the day ahead and week-ahead hourly MW production forecast. The forecasts shall be provided by each Renewable Power Plant by 10:00 a.m. on a daily basis for the following 24 hours and 7 days for each 1 hour time-period, by means of an electronic interface in accordance with the reasonable requirements of the TSO's data system.

9.12Transitional Provisions

Some existing generators and generators already purchased prior to approval by LEWA of the Lesotho Transmission Grid Code but not yet delivered and operational may not be able to immediately comply with the full requirements this Renewable Power Plants Code. Those renewable generators, if any, which cannot comply immediately shall notify LEWA and the Transmission System Operator and shall negotiate with the Lesotho Transmisssion System Operator a schedule for achieving compliance, subject to approval by LEWA.

Renewable generators purchased after the approval date of the Lesotho Transmission Grid Code shall comply with the requirements including this Renewable Power Plants Code, Sections 9.1 – 9.11.