GUIDELINES FOR GRID INTERCONNECTION OF SMALL POWER PROJECTS IN TANZANIA

PART A:
MANDATORY REQUIREMENTS AND TEST PROCEDURE

DRAFT

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ENERGY AND WATER UTILITIES REGULATORY AGENCY

CONTENTS OF PART A

- Harmonize defined terms throughout the document

LIST OF FIGURES IN PART A

LIST OF TABLES IN PART A

LIST OF ANNEXES TO PART A

Bibliography

INTRODUCTION

These Guidelines for the Grid Interconnection of Small Power Projects in Tanzania should be read in conjunction with *Guidelines for Developers of Small Power Projects (SPP) in Tanzania*.

These Guidelines are in three Parts:

Part A: Mandatory Requirements and Test Procedure

Part B: Technical Guidelines

Part C: Appendix

ASSOCIATED DOCUMENTS AND PUBLICATIONS

1. Guidelines for Developers of Small Power Projects (SPP) in Tanzania
2. Standardised Small Power Purchase Agreement(SPPA) for the Purchase of Grid-Connected Capacity and Associated Energy[1]
3. Standardised Small Power Purchase Agreement(SPPA) for the Purchase of Capacity and Associated Energy to Mini-grids

The purpose of these Guidelines is to establish procedures and equipment to protect personnel, equipment and the Distribution Network Operator's (DNO's) systems from any harmful effects arising out of the interconnection and operation of Embedded Generators. These guidelines would satisfy all the protection requirements of Embedded Generators.

All SPPs connected to the distribution network in Tanzania would be considered as Embedded Generators.

[1] The model SPPA was formally approved by the EWURA Board of Directors on December 30, 2008 in Order 08-15.

GLOSSARY, DEFINITIONS AND ABBREVIATIONS

AVC	Automatic Voltage Controller
AVR	Automatic Voltage Regulator
Captive Generation	Generating plant available at customer facilities, but not connected in parallel with the distribution network.
Captive Line Load	Load, up to the 1st point of automatic isolation, which is (or may be) supplied by an Embedded Generator, excluding Captive Local Load.
Captive Local Load	Load within the Embedded Generator premises including generator auxiliaries.
Captive Load	The sum of Captive Line Load and Captive Local Load
Combined Heat and Power (CHP)	A plant that generates electricity and supplies thermal energy, typically steam, to an industrial or other heating or cooling requirement.
Distribution Network	A public electricity supply network operating at or below 33 kV, connected to Tanzania's main grid or operating as an isolated mini-grid.
DNO:Distribution Network Operator	Licensee responsible for the operation of a distribution network in Tanzania.
EF	Earth Fault (protection)
EG	Embedded Generator
Embedded Generator	A single generator, or a group of generators, connected to the DNO's distribution network, of capacity range and interconnection voltages stated in Section A2 of the guidelines.
Export of Electrical Energy	Supply of Electrical Energy by a Generator to a Distribution Network.
Generating Company	A company, a group or an individual who plans to connect or has already connected an Embedded Generator to a Distribution Network.

Grid Interconnection	A link between a Distribution Network and the Embedded Generator's electricity system, made for the purpose of Exporting or Importing Electrical Energy.
Grid Substation	A substation in the main grid where electrical energy at 220 kV, 132 kV or 66kV is transformed into 33 kV or 11 kV.
Highest (Lowest) Voltage of a System)	The highest (lowest) value of operating voltage which occurs under normal operating conditions at any time and at any point in the system.
HV	High voltage, exceeding 1000 V between conductors and 600 V between conductors and earth.
Import of Electrical Energy	Receipt of Electrical Energy by the Embedded Generator from a Distribution Network.
Interconnection Certificate	A Certificate issued by a Distribution Network Operator to an Embedded Generator, after testing the Grid Interconnection.
Interconnection Voltage	The nominal voltage at which the grid interconnection is made.
Islanding	The process whereby a power system is separated into two or more parts, with generators supplying loads connected to some of the separated systems.
Islanded Operation	The situation that arises when a part of the Distribution Network is disconnected from the grid and is energised by one or more generators connected to it.
LOI: Letter of Intent	Issued by a Distribution Network Operator to a Generating Company to signify the intent to purchase power from a Generating Company at a particular location.
LOM	Loss of Mains (protection)
LV	Low voltage, not exceeding 1000 V between conductors and 600 V between conductors and earth.
Mini-grid	An isolated power system not connected to the Tanzania national grid, and operated under the regulatory supervision of Energy and Water Utilities Regulatory Authority.

Neutral Point Displacement Voltage	The voltage between the real or virtual neutral point and the earth.
NVD:Neutral Voltage Displacement	A technique to measure the displacement of the neutral voltage with respect to earth.
Nominal Voltage	A suitable approximate value of voltage used to designate or identify a System.
OC	Over-current (protection)
OF	Over-frequency (protection)
Operating Voltage	The value of the voltage under normal conditions at a given instant and at a given point in the system.
OV	Over-voltage (protection)
Point of Common Coupling (PCC)	The location of the connection between a Distribution Network and the Embedded Generator, beyond which other customer loads.
Point of Supply (POS)	The location of the connection between a Distribution Network and an Embedded Generator.
Power Purchase Agreement(PPA)	An agreement between the Distribution Network Operator and the Generating Company for the purchase of electricity.
ROCOF	Rate-of-change of Frequency (protection)
RP	Reverse Power (protection)
SBEF	Standby Earth Fault (protection)
Spinning Reserve	The difference between the total available capacity of all generating sets already coupled to a power system and their total actual loading.
Step Voltage	The difference in surface potential experienced by a person bridging a distance of 1 m with his feet without contacting any other grounded structure.

Touch Voltage	The potential difference between the ground potential rise (GPR) and the surface potential at the point where a person is standing, where at the same time having his hands in contact with a grounded structure. GPR is defined as the maximum voltage that a station grounding grid may attain relative to a distant grounding point assumed to be at the potential of remote earth. The touch voltage could be from hand to hand as well.
Transferred Voltage	This is a special case of the touch voltage where the voltage is transferred into or out of the station by a conductor grounded at a remote point or at the station ground, respectively.
TNS:Terra Neutral Separate (system of earthing)	In this earthing (grounding) system, the DNO provides separate neutral and protective conductors throughout the system. The protective conductor is connected to the neutral of the source. All exposed conductive parts of a consumer's installation are connected to the protective conductor provided by the DNO via the main earthing terminal of the consumer's installation.
TNO:Transmission Network Operator	Licensee responsible for the operation of transmission network in Tanzania.
TT:Tera Tera(system of earthing)	An earthing (grounding) system where all exposed conductive parts of an installation are connected to an earth electrode provided by the consumer which is electrically independent of the source earth.
UV	Under-voltage (protection)
UF	Under-frequency (protection)
Voltage Level	One of the Nominal Voltage values used in a given system.
VS	Vector Shift (protection)

A1 SCOPE OF THE GUIDELINES FOR GRID INTERCONNECTION

These Guidelines for Grid Interconnection of Small Power Projects is a comprehensive analysis of issues that may arise when connecting Embedded Generators to distribution networks in Tanzania, and provides guidelines on types of interconnection, voltages, studies required, protection requirements, and the testing and certification procedure of embedded generators.

For the purposes of these guidelines, an Embedded Generator is defined as a single generator or a group of generating plant with a total export capacity between 100 kW and 10 MW, connected to a Distribution Network in Tanzania, at 33 kV or below. For Embedded Generators of capacity less than 100 kW, a separate type approval requirement shall be implemented by the DNO.

These guidelines are intended to be followed by all Generating Companies building/operating Embedded Generators connected to a Distribution Network in Tanzania, irrespective of whether the Generating Company sells or intends to sell electricity to the Distribution Network Operator (DNO).

These guidelines do not replace or supersede any of the requirements specified in the Electricity Act, Electricity Regulations or Power Purchase Agreements.

A2 INTRODUCTION TO THE GUIDELINES FOR GRID INTERCONNECTION

Part A: Application Procedure and Mandatory Requirements

Part A of the guidelines specifies mandatory requirements to be satisfied by Embedded Generators connected to a Distribution Network in Tanzania.

Part B: Technical Guidelines

Part B of the guidelines provides useful information to Generating Companies and Distribution Network Operators (DNOs) in the design and acceptance testing of the grid interconnection of Embedded Generators.

Part C: Appendices

Part C contains explanatory notes that would be useful to study and design protection systems for Embedded Generators.

Protection equipment and systems specified in the guidelines are for the protection of the grid interconnection only.

A2.1 Capacity Limits and Interconnection Voltage

Requirements specified in these guidelines are applicable to all Embedded Generators with a maximum export capacity up to and including 10 MW, and for connection to a Distribution Network at or below 33 kV. For the purpose of this Guide, the 10 MW limit should be understood as the total export generating capacity connected to the network through a single Point of Supply (POS). The total generating capacity may consist of several generators. The maximum embedded generation allowed at different voltage levels are given in the Table A1.

Table A 1- Capacity Limits of Embedded Generation

Voltage Level	Maximum Embedded Generation Capacity Exported through a Point of Supply (POS)	Metering at
400 V	250 kW	400 V
11 kV	5 MW	11 kV
33 kV	10 MW	33 kV
66 kV (as a special case)	Capacity to be decided by the DNO and the generating company.*	66 kV

*Present regulatory guidelines allow only a capacity of 10 MW under the Small Power Projects

A2.2 Higher Capacities, Voltages and Upgrades

When the total export generating capacity at the Point of Supply exceeds 10 MW, either at the time of first interconnection of the Embedded Generator or as a result of an upgrade, the requirements of these guidelines will no longer be directly relevant. Similarly, when the interconnection is at a voltage higher than 33 kV, these guidelines may not be directly applicable. Such requirements will be specified by the Transmission Network Operator (TNO) on a case by case basis, or will be based on other prevailing requirements, standards or guidelines.

A2.3 DNO's Discretion to Waive the Requirements

The DNO may waive any one or several of the requirements of these guidelines for any Embedded Generator under any one or several of the following conditions.

(a) The Embedded Generator is designated to serve a short-term, emergency requirement of the Distribution Network, to ensure continuity of electricity supply
(b) The Embedded Generator is specifically for short-term research purposes.

In any event, all Embedded Generators are mandated to operate with protection against,

- Over and under voltage
- Over and under frequency
- Islanding Mitigation Protection for Embedded Generators larger than 1 MW

A2.4 Designated Officers

The DNO will designate a competent officer to:

- witness that the requirements of these guidelines are fulfilled at the time of first interconnection, and
- coordinate with the Generating Company who have the responsibility to ensure that the requirements are adhered to on a continuous basis.

A3 EMBEDDED GENERATION

A3.1 Embedded Generators in a Distribution Network

Embedded generators are typically small and medium sized generators connected to a Distribution Network. There may also be captive loads. The interconnection voltage would be 400 V or 11 kV or 33 kV. Connection to 66 kV shall be considered as a special case, for which the protection requirements are not specified in these guidelines.

A3.2 Islanded Operation

For the purpose of these guidelines, islanded operation means the situation that arises when a part of the electrical system is disconnected from a Distribution Network and is energised by the embedded generation connected to it. Prolonged islanded operation in a DNO's system is unsafe and should be prevented by suitable means of protection. Details of islanded operation detection and protection are given in Part B of these guidelines.

A3.3 Availability of Capacity

There is no central control, or dispatch of Embedded Generators. Generation plant power output is controlled by the operator and connection availability. Plant will usually be run at the maximum power available from the primary source of energy. The requirement for some central control of embedded generation capacity shall be reviewed when the total embedded generation capacity exceeds 10% of the total minimum load of the Tanzania main grid.

A4 CONTEXT

A typical distribution network connected to the main grid and a mini grid network when embedded generators are connected are shown in Figures A1 and Figure A2, respectively.

A4.1 System Reliability and Stability

Most embedded generators are expected to be connected to long, overhead, radial lines, where the frequency of disconnection is high. Daily disconnections are common. Transmission/generation failures are frequent in the main grid, and these at times result in frequency excursions, frequency dips and under frequency load shedding.

A4.2 Types of Connection

Embedded generating plants covered in these guidelines are of two types, as described below.

A4.2.1 Type 1: Embedded Generators with a Substantial Captive Local Load

These generators will regularly operate in parallel with the distribution network, but supply the power requirements of a localised industry or other facility. The connection will be through the Point of Supply from the distribution network to the captive local load.

Hydroelectric power plants located within tea factories and biomass-fired power plants located in sugar industries are examples of this type of Embedded Generator.

A4.2.2 Type 2: Embedded Generators with Minimal Captive Local Load

These are Embedded Generators specifically built to harness a primary source of energy. These generators are typically connected to the distribution network through a dedicated line. There will be no other customer loads between the Point of Common Coupling and the Embedded Generator. The Embedded Generator is always operated in parallel with the distribution network.

A4.2.3 Separate Agreement Required to Import Energy

Embedded Generators should enter into a service agreement with the DNO for the import of energy for its own requirements.

Figure A 1- A Typical Distribution Network in the Main Grid with Embedded Generators

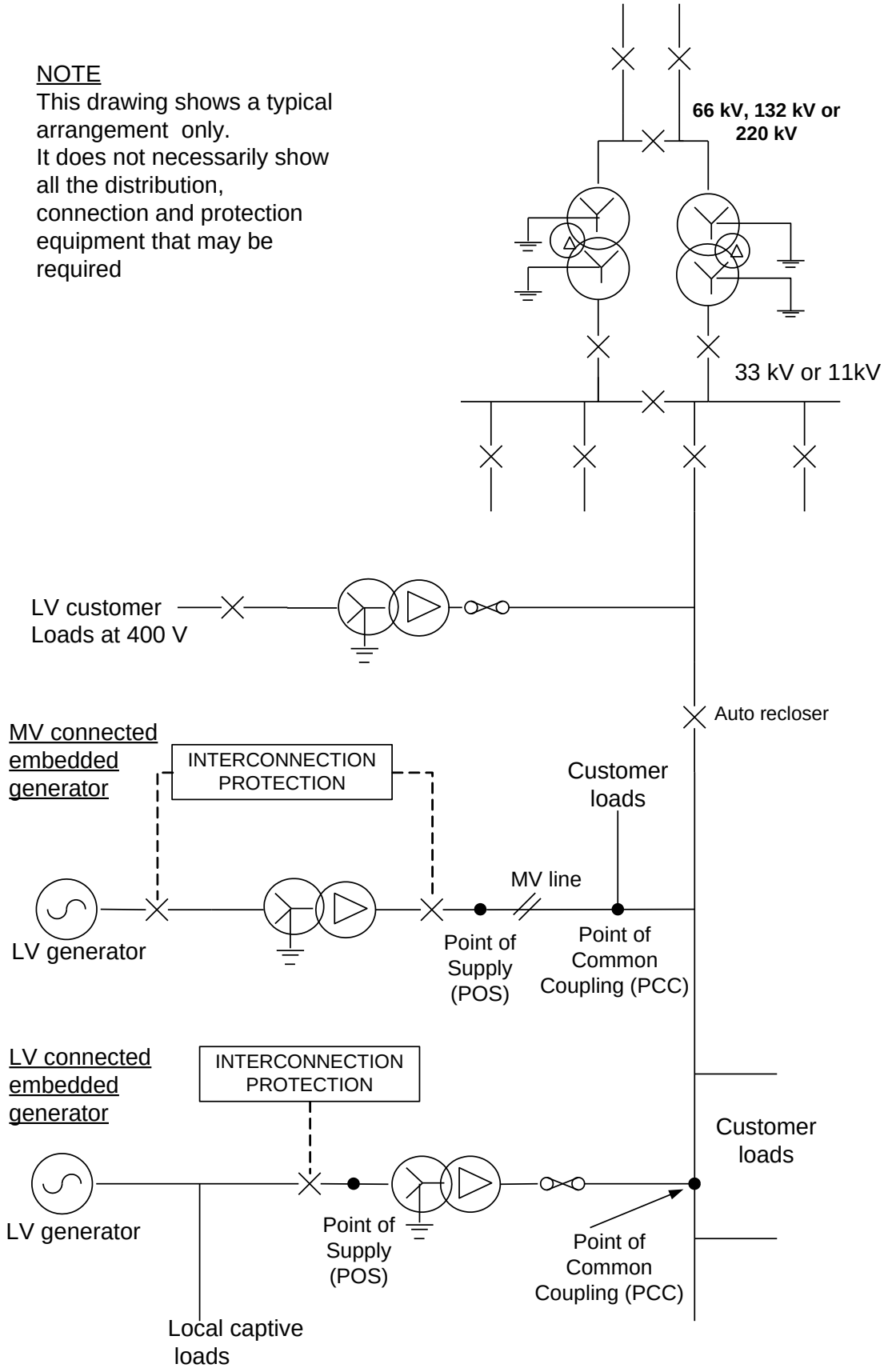
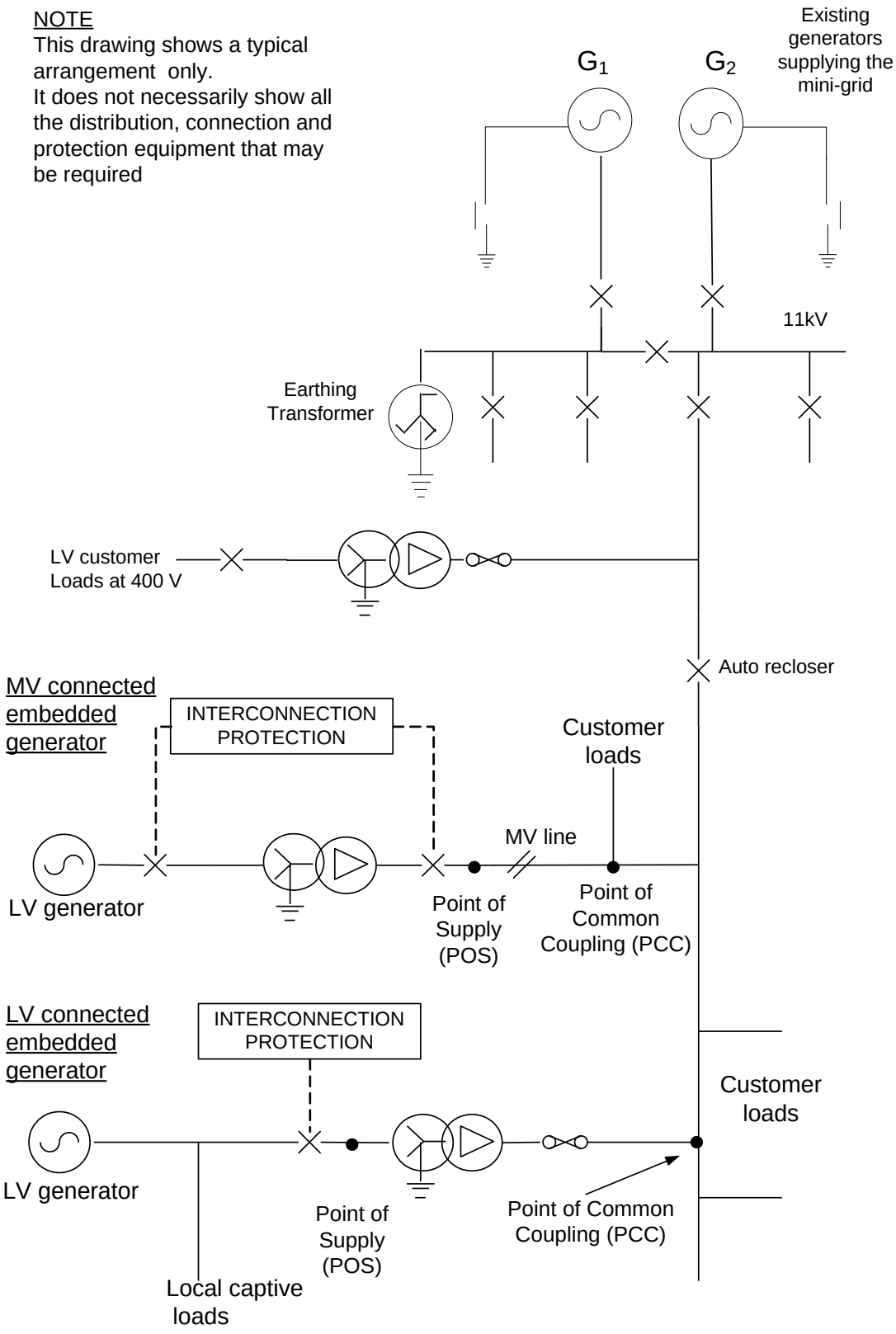


Figure A 2- A Typical Isolated Mini-grid with Embedded Generators



A4.3 Capacities and Locations

Embedded Generators are typically located away from grid substations of the main grid. Often there are long lines, supported on wooden poles, concrete poles or steel pylons, between the Embedded Generator and the nearest grid substation or the distribution line. Typically there are only a few customer loads on these lines, mostly supplying to households or small commercial customers.

A5 PROCEDURE FOR GRID INTERCONNECTION

A flowchart showing the process on information exchange up the testing of grid interconnection is shown in Figure A3.

A5.1 Exchange of Technical Information on the Interconnection

A5.1.1 From Generating Company to the DNO

Within the period of validity of the Letter of Intent (LOI), and when the detailed specification of the Embedded Generator are being prepared, the Generating Company shall submit to the DNO, the technical data about the Embedded Generator, shown in Annex 1. The DNO may request additional, reasonably required, information from the Generating Company, over and above those included in Annex 1.

The Generating Company shall provide a single-line drawing of the electrical system of the Embedded Generating plant up to and including the Point of Supply. All protection relays and associated instrument transformers shall also be shown on the single-line drawing. A typical single-line drawing is shown in Figure 4.

The Generating Company shall also provide the DNO with the proposed settings of all protection relays and switchgear.

A5.1.2 From the DNO to the Generating Company

Following the issue of an LOI and after receiving the information shown in Annex A1 from the Generating Company, the DNO, after satisfying itself that the detailed design of the Embedded Generator is in progress, shall conduct the necessary studies, including those explained in Section B1 of the guidelines, and provide the required information to the Generating Company.

Figure A 3- Procedural Flow Chart of Embedded Generator Grid Interconnection

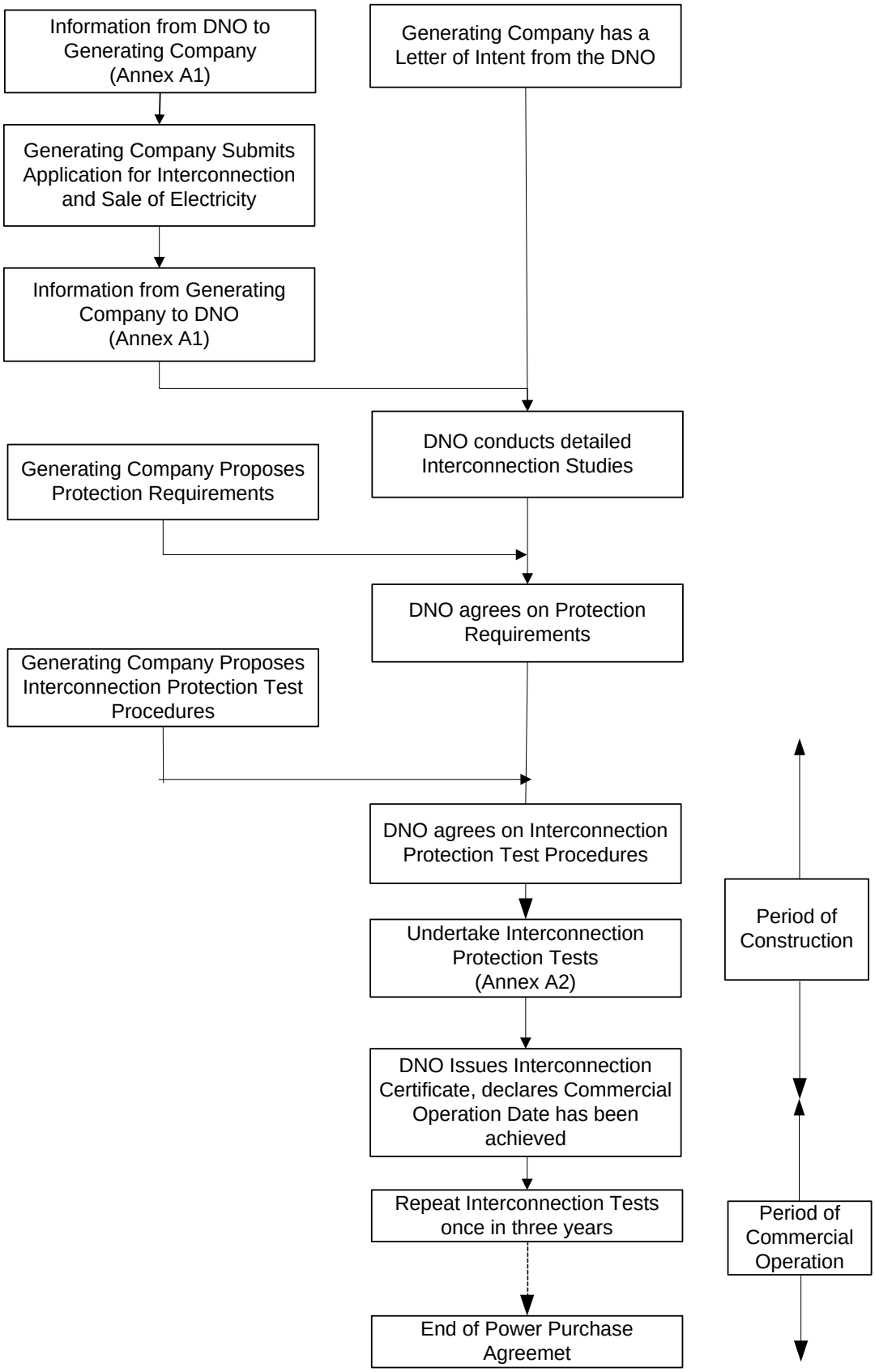
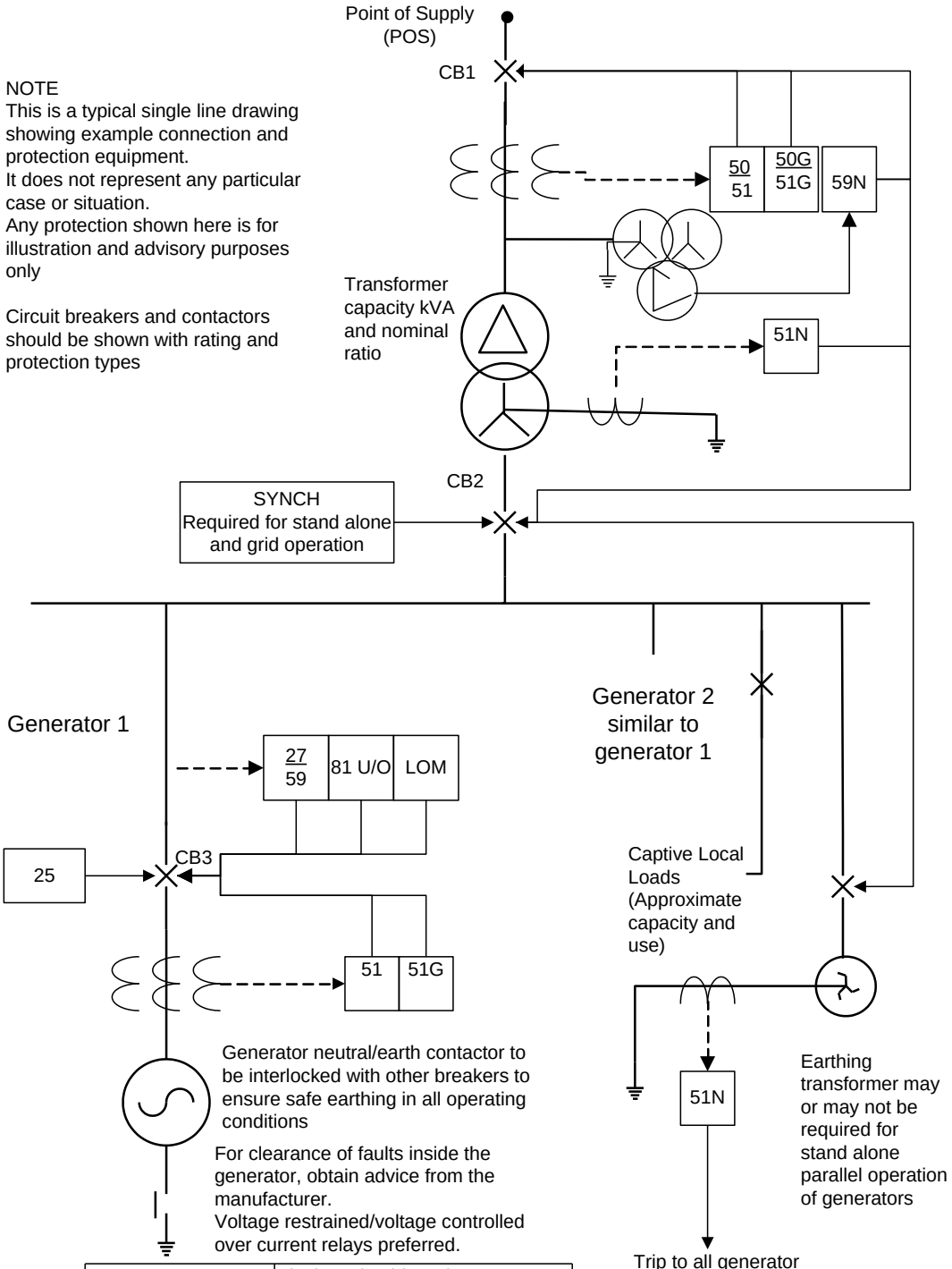


Figure A 4 - A Typical Single Line Diagram of Embedded Generator Interconnection



25	Check Synchronizing Relay
27/59	Under Voltage & Overvoltage Relay
50/51 50N/51N	Phase & Ground Overcurrent Relay
59N	Neutral Voltage Displacement
81 U/O	Underfrequency & Overfrequency Relay
51N	Standby Earth Fault Relay
51G	Earth Fault Relay
CB	Circuit Breaker
LOM	Loss of Mains

A5.2 Annual Summary of Operation Information

Embedded Generators are usually not within the purview of the dispatch control of the grid operator or the distribution network operator. However, Embedded Generators shall provide the following information to the DNO on an annual basis, within the period of a valid PPA.

The aim of providing this information is for the DNO to establish a database to assist in their planning of system operations.

At the end of each year of operation,

(a) Net energy export to the DNO in kWh
(b) Maximum and minimum net power export in kW
(c) List of outages, with date, time, duration, probable cause (identifying whether external or internal), damages (if any)
(d) Planned outages (purpose, date, duration) over twelve calendar months ahead
(e) Expected date of reconnection if there are long-term outages, partial or total, at the time of submission of information.

In addition to the above information, obligations to provide an annual forecast of the operation of the Embedded Generator, specified in the PPA, should be fulfilled.

On Embedded Generators larger than 3 MW: provide information monthly, within a month from the last day of each calendar month.

On Embedded Generators equal to or less than 3 MW: provide information annually, within one month from the end of the calendar year.

A5.3 Metering

A5.3.1 Type of Meter

Meters used for the measurement shall be based on digital technology and provision should be made by the Generating Company and DNO to enable on-line data transfer to the Load Dispatch Centre and any special monitoring unit established by the DNO to facilitate the development of renewable energy.

A5.4 Metering to be at the Point of Supply

Energy and other metering required to measure the power transfer between the distribution network and the Embedded Generator shall normally be at the Point of Supply. An alternative metering point may be agreed between the DNO and the

Generating Company. This agreement may include an allowance for the increase or reduction in losses to the DNO due to the change in the metering location.

A5.4.1 Metering Equipment Costs

The costs for purchase of meters and metering equipments shall be borne by the Generating Company. Meters may be operated and maintained by DNO.

A6 MANDATORY PROTECTION REQUIREMENTS

Table A2 summarises the mandatory requirements of protection. See Part B for technical guidelines to fulfil these protection requirements.

Table A 2- Summary of Minimum Protection Requirements

	Case 1	Case 2	Case 3	Case 4	Case 5	
Generator type	**All**	**All**	**See Case 3 description**	**All**	**See Case 5 description**	**Self commutated static inverters**
Minimum captive load	L	L	L		L	
Maximum cumulative installed capacity	<0.5 x L	<0.8 x L	>0.8 x L		>0.8 x L	
Maximum site installed capacity	< 5 MW	< 5 MW	< 5 MW	> 5 MW		
Under and over voltage protection	●	●	●	●	●	
Under and over frequency protection	●	●	●	●	●	
Loss of Mains	*	●	●		●	
NVD protection			●	*(1)		
Intertripping				*		
Loss of Phase	●	●	●	●	●	●
Other	*		*	*	*	*

- ● Mandatory minimum requirement

  * For other requirements and alternatives see the descriptions under the respective case descriptions and requirements

(1) NVD or parallel earthing

A7 IMPLEMENTATION OF THE GUIDELINES

A7.1 Distribution Network Operator to Implement the Guidelines

The DNO will implement the requirements of these guidelines where an Embedded Generator is connected to the distribution network. The DNO reserves the right to disconnect Embedded Generators that do not conform to the requirements specified in these guidelines.

A7.2 Revisions

These guidelines may be revised by EWURA from time to time, and it is the responsibility of Embedded Generators to ensure that the Grid Interconnection complies with the latest version of the guidelines.

Any costs incurred by the Generating Company in complying with the revisions to the guidelines shall be borne by the Generating Company.

A8 EFFECTIVE DATE

The requirements of the guidelines will apply to all Embedded Generators connected to a distribution network from 1st January 2009.

Embedded Generators with a valid Interconnection Certificate shall be connected to and/or operate in parallel with the distribution network only with.

A9 INTERCONNECTION CERTIFICATE

A9.1 DNO to Issue the Certificate

The DNO shall issue an Interconnection Certificate after the tests required in these guidelines are performed.

A9.2 Interconnection Certificate

The **Embedded Generator Test Record** of the form given in Annex A2 should be attached to the Interconnection Certificate. The originals of the Interconnection Certificate and the Embedded Generator Test Record shall be retained at the address shown in the Interconnection Certificate and the Test Record.

A9.3 Validity

The Interconnection Certificate is valid for a period of three (3) years from the date of the Embedded Generator Test Record, after which, the Generating Company shall arrange a fresh test to be conducted and request the DNO for a fresh Interconnection Certificate to be issued.

The DNO reserves the right to inspect the protection systems of the interconnection, any time during the period of validity of an Interconnection Certificate.

A9.4 Designated Officers

The DNO will designate an officer or officers to witness the interconnection tests specified in these guidelines, and to issue an Interconnection Certificate. The DNO may also designate one or several third party certification bodies or individuals to perform the necessary inspection and testing, to witness the tests, and to recommend to the DNO about the issue of the Interconnection Certificate.

A9.5 Testing and Acceptance Procedure

Testing and Acceptance Procedures are explained in Section A10.

A9.6 Costs and Fees of Interconnection Tests and Certificate

The cost of conducting the Interconnection Tests either by the DNO or their designated third party certification bodies or individuals, will be met by the Generating Company. The DNO may charge a fee for the issue of an Interconnection Certificate.

A10 TESTING AND ACCEPTANCE PROCEDURES

A10.1 General

This section of the guidelines covers:

- guidelines for testing and acceptance
- information requirements before testing
- personnel requirements and test witnessing
- standard forms to be completed

A10.2 Responsibilities and Witnessing

The Generating Company will nominate a qualified person to act as their representative for protection inspection and testing.

The DNO will nominate a qualified person to act as his representative to witness protection testing. This person will coordinate with the Generating Company representative, to agree on the test procedures and equipment to be used for testing.

It is the responsibility of the Generating Company representative, to organise, agree procedures with the DNO and undertake protection equipment testing. The Generating Company may use staff and equipment made available by the DNO, or a third party, to assist in the tests.

Prior to testing, the Generating Company representative will certify by signature that,

(i) the earthing system conforms to the provisions in these guidelines and other relevant standards.
(ii) the design and implementation of the generation and protection system complies with the requirements of the guidelines, and any protection specified in the PPA.
(iii) the generating system is safe to operate and complies with all the relevant requirements for electrical installations.
(iv) the commissioning tests have been completed, including all CT and VT ratio testing.

It is the responsibility of the Generating Company representative to provide and complete the test forms.

The Generating Company representative should give as much notice as possible of the requirement for testing. The DNO shall make a suitable representative available within two (2) weeks of notice by the Generating Company that testing is required.

Testing is to be witnessed by the DNO's representative. The DNO's representative shall certify by signature that the protection tests were witnessed as successful.

A10.3 Test Procedures

The test procedures shall be proposed by the Generating Company. They will be agreed between the Generating Company representative and the DNO's representative prior to the testing date.

The procedures will be designed to demonstrate the operation of all the protection functions required by these guidelines and specified in the PPA between the Generating Company and the DNO.

The procedures will include, as appropriate:

- Earthing System

- Secondary injection of test voltages and currents into test relays and the operation of the relays observed
- Demonstration that the operation of a protection relay opens or inhibits the closure of the appropriate breaker or contactor.
- Primary current injection tests, where practical, to demonstrate the ratio of CTs and the continuity of CT wiring.
- Other tests as required (for example earth resistance, insulation resistance, contact resistance)

A single-line drawing of the installation showing the main power connections, breakers, contactors, VTs, CTs and protection relays shall be provided by the Generating Company to the DNO prior to the test day. A copy of this drawing is to be made available at the site at all times.

A detailed protection arrangement drawing shall also be provided by the Generating Company.

The test equipment used for measurements during testing shall be suitably calibrated and have a valid calibration certificate. The Embedded Generator Test Record to be completed for acceptance testing and subsequent tests is given in Annex A2.

A10.4 Test Intervals

The required grid connection protection is to be tested at the following times:

(i) Prior to acceptance of new generation plant for connection to the distribution network. Short term connection may be allowed to set up and test the protection equipment.
(ii) Re-testing at intervals of no greater than three years to enable a new Interconnection Certificate to be issued.
(iii) Following any significant change in generation or protection equipment.
(iv) Following any maintenance or repair, which involved the disconnection or rearrangement of any protection equipment.

When re-testing is undertaken, the protection settings set at the original commissioning shall be entered on the test record form.

A10.5 Records

A written record in the form of Embedded Generator Test Record (Annex A2) shall be maintained by the Generating Company. The storage location of this original record shall be stated on the Test Record. A copy of this Test Record shall be provided to the DNO. The Test Record will cover all the tests required.

Annex A 1 – Forms for Information to be Exchanged

(a) Information to be Provided by the [DNO] to the Generating Company

This information shall include the planned (or prospective) fault levels expected by the [DNO] in 10 years from the time of connection application.

Site Name ……

Site Reference Number ……

Location ……

Generating Company Name ……..……

Contact ……

Point of Supply (location) …..……

Maximum fault levels (for equipment selection and earthing design):
Network design symmetrical fault level (kA or MVA) ……

Peak asymmetrical fault level at half cycle (kA) ……

3-phase symmetrical fault level at half cycle (MVA or kA) ……

X/R ratio for 3 phase symmetrical fault ……

1-phase to earth fault level (kA) (neglecting earth system resistances)
..……

X/R ratio for 1-phase to earth fault. (neglecting earth system resistances)
..……

Minimum fault levels (for protection design):
3-phase steady state symmetrical fault level (MVA or kA) ……..

X/R ratio for 3 phase symmetrical fault ……

1-phase to earth fault level (kA) (Neglecting earth system resistances)
……
X/R ratio for 1-phase to earth fault (neglecting earth system resistances)
..……..

(b) Information to be Provided by the Generating Company to [DNO]

b.1 For synchronous generators with an installed capacity ABOVE 500 kW

Site Name ……

Location ……

Site Reference Number ……

Generating Company Name……

Contact ……

Point of Supply (location) ……

Maximum export capacity ……

Maximum import capacity ……..

Power factor operating range ……

Generator (for each synchronous generator):

Terminal voltage (kV) ……..
Machine rating (MVA) ……
Stator resistance (pu) …… tolerance % …….
Sub-transient reactance (pu) …… tolerance % …….
Transient reactance (pu) …… tolerance % …….
Synchronous reactance (pu) …… tolerance % …….
Sub-transient time constant (ms) …… tolerance (ms) …….
Transient time constant (ms) …… tolerance (ms) …….

Transformer (for each generator transformer);

Rating (MVA) ……..
Reactance (pu) …….. tolerance % …….
Resistance (pu) …….. tolerance % …….
Voltage Ratio …….. vector group …….

Cable or Line between the Generator and Point of Common Coupling where this cabling distance exceeds 50 metres

Voltage (V) ……..
Reactance (Ohm) …… Resistance (Ohm) ……

Information to be Provided by the Generating Company to [DNO]

b.2 For synchronous generators with an installed capacity BELOW 500 kW

Site Name ……

Location ……

Site reference ……

Generating Company Name……..

Contact ……

Point of Supply (location)……

Maximum export capacity (kW) ……

Maximum import capacity (kW) ……..

Power factor operating range ……..

Generator (for each synchronous generator):
Terminal voltage (kV) ……..

Machine rating (MVA) ……..

Stator resistance (pu) ……..

Transformer (for each generator transformer);
Rating (MVA) ……..

Reactance (pu) ……..

Resistance (pu) ……..

Voltage Ratio …….. Vector group ……

Cable or Line between the generator and Point of Common Coupling where this cabling distance exceeds 50 metres
Voltage ……..
Reactance (Ohm) …….. Resistance (Ohm) ……..

Annex A2– Embedded Generator Test Record

Note: Full details are required of all generators to be tested. A separate copy of this form shall be used for each generator.

1. Site Information

Site Reference Number ……..

Generator identification or number (if more than one generator at the site)

…….....……..…

2. Generating Company Details:

Name and Address:
…….....……..…

….....……..…

Telephone Numbers and Contact Person……..

…….....……..…….....

The original of this document is stored at: ……..…….

3. [DNO] Details:

Name and Address of Contact Person:
…….....

…….....

4. Names of Representatives

Generating Company representative

Name …….....

Designation …….....……

Manufacturer's Representative (optional) Name …….....

Designation …….....……..

[DNO] **Witnessing Engineer**

Name ……..... ……

Designation …….....……..

5. [DNO's] **Supply Details**

Voltage .....

Maximum Fault Level .....

Point of Common Coupling location .....

Point of Supply location .....

Point of Syncronisation location shall be.....

6. Generating Plant Details

Type (synchronous, asynchronous, inverter) .....

Manufacturer .....

Serial No. .....

Rated:

Voltage (V) .....

Current (A) .....

Frequency (Hz) .....

Power Factor .....

Capacity (kVA) .....

Output Winding Delta or Star .....

Earthing arrangement.....

.....

.....

.....

7. Protection details

Check availability of single line drawing and protection drawings ☐ tick

8. AVR and Power Factor Control

Record details of the mode agreed for the generator AVR and Power Factor control operation or constraints placed on output.

.....

.....

.....

.....

9. Installation Inspection:

Measured earth resistance from commissioning: …… ohm

Earth continuity checked ☐ tick
(Generating Company to provide a commissioning or test record)

Earth bonding of all equipment is satisfactory ☐ tick
(Main bonding viewed by Witnessing Engineer)

Generator neutral earthed in isolated mode ☐ tick

Generator neutral disconnected when connected to the grid ☐ tick

View rating and settings of main breakers and fuses ☐ tick

Generator isolating switch is lockable in the OFF position,
and provides suitable safe isolation ☐ tick

If this is the first acceptance test of the plant following construction and commissioning, or following major maintenance or upgrading, the Witnessing Engineer should have sight of all appropriate commissioning test documentation. Particularly relating to interconnection protection relays and their sensing CTs and VTs, as appropriate

☐ tick

Nominal Voltage for test and measurement …….…… V

(calculate the nominal test voltage from the HV voltage and the transformer ratio, if this is an HV connection. For an LV connection, the nominal test voltage is 230V)

10. Protection Relay Tests

Identify which interconnection protection relays have been specified and fitted. List here the interconnection protection functions that have been implemented, and the maximum and minimum relay operation levels, that have been specified for this site. The levels will be those specified in the guidelines unless by other agreement.

For example:

“RoCoF …….. Hz/second” “Undervoltage …….%, overvoltage ……. %”

……

……

……

……

- Complete the tripping tests of the protection relays and record the test results on the following pages.
- The testing is to demonstrate the operation of the interconnection protection relays as required by the guidelines.
- The testing is not intended to verify detailed relay performance such as levels of pick up and drop off.
- The generator should be off and isolated during the following tests on Interconnection Protection.

Operation Time Recording

- The operating time for each relay test shall be recorded.
- The operating time of the relay shall be measured, including any delay set in the relay.
- If practical, the operating time should be measured as far as the auxiliary contacts on the appropriate breaker, and include any time delay units or other features.
- The time being measured for each test shall be recorded with each test.
- The total maximum tripping time specified in the guidelines includes the operation time of the appropriate breaker.

The breaker operating time is: …… ms (from commissioning tests)

EMBEDDED GENERATOR PROTECTION CALIBRATION AND TRIPPING TESTS

OVERVOLTAGE

MANUFACTURER …….. TYPE ……

SERIAL NUMBER ……

	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
Line or phase tested	Volt	Time (ms)	Volt	Time (ms)	Volt	Time (ms)	
R-N OR R-Y							
Y-N OR Y-B							
B-N OR B-R							

* Show designed values, if the present test is the first Acceptance Test.

UNDERVOLTAGE

MANUFACTURER …….. TYPE ……

SERIAL NUMBER ……

	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
Line or phase tested	Volt	Time (ms)	Volt	Time (ms)	Volt	Time (ms)	
R-N OR R-Y							
Y-N OR Y-B							
B-N OR B-R							

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT

State what time is being measured, e.g. relay only or relay and breaker auxiliary"

……

……

MEASURING EQUIPMENT

Type …… Serial number ……

Valid calibration certificate seen: Yes/No

OVER FREQUENCY (SPEED)

MANUFACTURER …….. TYPE ……

SERIAL NUMBER ……

	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	Hz	Time (ms)	Hz	Time (ms)	Hz	Time (ms)	
PHASE TESTED ……							

* Show designed values, if the present test is the first Acceptance Test.

UNDER FREQUENCY

MANUFACTURER …….. TYPE ……

SERIAL NUMBER ……

	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
	Hz	Time (ms)	Hz	Time (ms)	Hz	Time (ms)	
PHASE TESTED ……							

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT

State what time is being measured, e.g. “relay only” or “relay and breaker auxiliary”

……

……

MEASURING EQUIPMENT

Type …… Serial number ……

Valid calibration certificate seen: Yes/No

LOSS OF MAINS- ROCOF

LOSS OF MAINS FUNCTION …….. MANUFACTURER ……..

TYPE …… SERIAL NUMBER ……

	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
PHASE	Hz/s or angle degrees	Time Delay (ms)	Hz/s or angle degrees	Time Delay (ms)	Hz/s or angle degrees	Time Delay (ms)	

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT
State what time is being measured, e.g. “relay only” or “relay and breaker auxiliary”
……

MEASURING EQUIPMENT
Type …… Serial number ……
Valid calibration certificate seen: Yes/No

LOSS OF MAINS- VECTOR SHIFT

LOSS OF MAINS FUNCTION …….. MANUFACTURER ……..

TYPE …… SERIAL NUMBER ……

	MEASURED VALUES AT FIRST ACCEPTANCE*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
PHASE	angle degrees	Time Delay (ms)	angle degrees	Time Delay (ms)	angle degrees	Time Delay (ms)	

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT
State what time is being measured, e.g. “relay only” or “relay and breaker auxiliary”
……..

MEASURING EQUIPMENT
Type …… Serial number ……

Valid calibration certificate seen: Yes/No

LOSS OF MAINS- INTERTRIP

Ensure Inter-trip details are shown on the Single Line and Protection Drawings ☐ tick

Check existence of suitable voltage barriers on trip signal systems, if appropriate ☐ tick

Record details below, or on attached sheets no. …….., of each Inter-trip arrangement.

Operate intertrip from remote location and check signal and operation of the trip ☐ tick

NEUTRAL VOLTAGE DISPLACEMENT (NVD) (IF APPLICABLE)

MANUFACTURER …….. TYPE ……

SERIAL NUMBER ……

Test to be undertaken with NVD relay disconnected from VTs

	MEASURED VALUES AT COMMISSIONING*		PRESENT SETTING		VALUES RECORDED AT THE PRESENT TEST		TRIP SEQUENCE AND INDICATIONS
SECONDARY INJECTED VOLTAGE TO OPERATE	Volt	Time (s)	Volt	Time (s)	Volt	Time (s)	

* Show designed values, if the present test is the first Acceptance Test.

TIME MEASUREMENT
State what time is being measured, for example “relay only” or “relay and breaker auxiliary”

……
……

MEASURING EQUIPMENT

Type …… Serial number ……
Valid calibration certificate seen: Yes/No

NVD VT Operation

Demonstration of Operation of NVD

To demonstrate the operation of the NVD protection, the supply to the NVD detection VTs should be removed on the HV side.

Each phase should be disconnected in turn. Disconnection may be achieved by removing the HV fuse feeding the VT. When a phase is removed the NVD should operate and the breaker(s) tripped.

Red phase	☐	tick
Yellow phase	☐	tick
Blue phase	☐	tick

An experienced qualified person should undertake the removal of HV fuses.

If the above test results are acceptable to the DNO's Witnessing Engineer, the Generator may now be synchronised and connected to the grid.

11. Synchronization of Machine

Synchronization method: Auto/Manual

Check commissioning test record of grid and machine phase rotation, or undertake test now ☐ tick

12. Voltage Fluctuation at Synchronization

System Voltage	R-N or R-Y	Y-N or Y-B	B-N or B-R
Generator OFF			
Generator connected			

The voltage fluctuation should not exceed 3% at the Point of Common Coupling.

Machine load currents during this test

R .....A Y .....A B .....A

Voltage measuring equipment
Type …… Serial number ……

Current measuring equipment
Type …… Serial number ……..……...

13. Loss of Phase Protection

With the machine running and in parallel with the [DNO] system, remove each phase supply in turn, followed by a 3-phase disconnection. This test may be undertaken at any power level. Disconnection may not be effective at low power levels, in which case, restrictions on minimum sustained generator output may be made.

Red Phase	☐	Tick
Yellow Phase	☐	Tick
Blue Phase	☐	Tick
3 Phase	☐	Tick

The generator should stop and further operation be disabled until the grid or the relay is reset.

14. Loss of Tripping and Auxiliary Supplies

Prove all protection is 'fail safe' by de-energising the protection relay power supplies

Machine should shutdown and be unable to restart until the power supply is restored ☐ Tick

(Alternatively alarm to be made dead)

15. CERTIFICATION

On behalf of [the Generating Company], I certify that the generating equipment in the above has been installed and tested, and complies with the requirements of the Guidelines for Grid Interconnection of Small Power Projects, Tanzania.

Signature .....

Name: .....

Designation .....

Date .....

On behalf of [*Distribution Network Operating Co]*, I certify that I have witnessed the above tests.

Signature .....

Name: .....

Designation .....

Date .....

Exceptions

Details of any restrictions on power output.
Details of abnormal loads.
Note of changes or actions requested.
Indications of any future changes.
Record details of any power, voltage or current fluctuations.

Continue on a separate sheet if required and state number of sheets here

…… extra pages attached.

Notes

(a) These tests are to safeguard the [DNO's] distribution network. They do not certify that the whole installation has been tested, or meets the requirements of the Wiring Regulations, or any statutory requirements.
(b) The overvoltage and undervoltage protection should be tested using an external variable voltage supply.
(c) Where the frequency of the plant is dependent on the mains frequency, an external variable frequency signal generator, with suitable voltage and current output should be used for the under and over frequency protection tests.
(d) The loss of mains protection should be tested by application of a frequency ramp or step frequency change, in accordance with the manufacturer's instructions.

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