NRS 097-2-1:2024

Edition 3

GRID INTERCONNECTION OF EMBEDDED GENERATION

PART 2: SMALL-SCALE EMBEDDED GENERATION

SECTION 1: UTILITY INTERFACE

This document is not a South African National Standard

NRS Association

N R S

NRS 097-2-1:2024

This rationalized user specification is issued by
the Technical Governance Department, Eskom,
on behalf of the
User Group given in the foreword
and is not a standard as contemplated in the Standards Act, 1993 (Act No. 29 of 1993).

Table of changes

Change No.	Date	Text affected
1	July 2020	Changed EMC/EMI requirements in 4.1.13
2	July 2020	Insertion of new Figure 4 (NRS 097-2-1 emission limits)
3	July 2023	Major changes

Correspondence to be directed to

The Technical Governance Manager
Technical Governance
Eskom
Private Bag X13
Halfway House 1685

Telephone : (011) 651 6830
Fax : (086) 667 3084
E-mail : nrs@eskom.co.za

Website : https://scot.eskom.co.za

Foreword

This section of NRS 097-2 was prepared on behalf of the NRS Management Committee and approved by it for use by supply authorities.

This section of NRS 097-2 was prepared by a working group which, at the time of publication, comprised the following members:

Beukes J Dr (Chairman)	Eskom RT&D
Brandow F	City of Ekurhuleni
Cooper S	Cape Agulhas Municipality
de Beer G	Sasol
Govender V	Eskom
Groenewald H	Eskom
Herselman M	City of Tshwane
Jefferies I	City of Cape Town
Lamour B	Nelson Mandela Bay Municipality
Mpholo M	Mangaung Municipality
Moonsamy R	Eskom
Nundlal V (Project Leader)	NRS Project Management Agency (NRS PMA)
Pillay L	George Municipality
Raedani H	City of Ekurhuleni
Sewchurran S Dr	eThekwini Municipality
van Rooyen K	Eskom
van der Riet R	City of Cape Town
Vermeulen P	City Power Johannesburg (SOC) Ltd
Zondi L (Ms)	City of uMhlathuze

An industry interest group was consulted on the contents of this section of NRS 097-2 and its comments were incorporated where the working group was in agreement. The industry interest group comprised the following members:

Anderson A	Trackos
Bekker B Prof	University of Stellenbosch
Benjamin B	SMA Solar
Bosman A	Fibon Energy
Botha G Dr	Northwest University
Burger I Dr	Solarfuture
Fourie H	ABB
Kossak B	Fronius
la Cock F	Solaredge
Monk L	Schneider-Electric
Seedat M	Fronius
Mushwana C	CSIR
Mwanza C	NERSA
Yeshaya A	Solaredge

This section of NRS 097-2 was approved by the NRS Management Committee which, at the time of publication, comprised the following members:

Padayachee V (Chairman)	Association of Municipal Electricity Utilities of Southern Africa (AMEU)
Dlamini J	South African Bureau of Standards (SABS)
Ferrier R	Buffalo City Metropolitan Municipality
Kgopa M	National Energy Regulator of South Africa (NERSA)
Lamour B	Nelson Mandela Bay Municipality
Mostert H	City of Cape Town
Naicker J	NRS Project Management Agency (NRS PMA)
Naidoo L	Eskom Transmission
Nkambule T (Ms)	Eskom Distribution

Ramnarain V	eThekwini Municipality
Raseboka S	City Power Johannesburg (SOC) Ltd
Rasetlola M	City of Tshwane
Rikhotso C	City of Ekurhuleni

NRS 097 consists of the following parts and sections, under the general title *Grid interconnection of embedded generation:*

Part 1: Distribution standard for the interconnection of embedded generation.

The specification sets out the minimum technical and statutory requirements for the connection of embedded generators to medium-voltage and high-voltage utility distribution networks. The specification applies to embedded generators larger than 1 MVA. (To be developed in the future.)

Part 2: Small-scale embedded generation.

The specification sets out the technical requirements for the utility interface, the embedded generator and the utility distribution network with respect to embedded generation. The specification applies to embedded generators smaller than 1 MVA connected to low-voltage networks.

Section 1: Utility interface.

Section 2: Embedded generator requirements. (To be developed in the future.)

Section 3: Simplified utility connection criteria for low-voltage connected generators.

Section 4: Procedures for implementation and application. (In development).

In the definition of “utility”, reference is made to the “electricity distribution supply authority”. In South Africa this may be Eskom, or the municipal electricity service provider.

Introduction

Embedded generation refers to generation and storage embedded in the utility distribution network that operates in parallel with the utility supply. An embedded generator with nominal capacity of less than 1 000 kVA, connected to a single-phase, dual phase, or three-phase low-voltage supply is defined as a small-scale embedded generator (SSEG). Parallel operation means that both the SSEG and the utility are able to supply power to the same AC system at the same time. Uninterrupted power supplies having parallel operation as one of their operating modes are also regarded as SSEGs. A solar PV or bi-directional battery system operating in parallel to the utility supply is defined as SSEG, even if the system is software configured to never inject current into the utility supply.

When a system is not synchronised to the utility supply or its hardware architecture makes it impossible to inject current into the utility supply, for example certain double conversion or offline uninterrupted power supplies or certain battery chargers, it is not defined as SSEG.

Systems that transfer power delivery from only the utility or only a generator are covered in SANS 10142-1 as alternative supplies.

Although it is expected that this specification mainly applies to photovoltaic systems interfaced through inverters, power can be converted by using non inverter-based technologies, such as induction generators and synchronous generators. This specification also applies to these technologies. Inverters can also be utilized to convert power produced by wind, hydro, battery energy storage, etc. to grid compatible electrical power.

According to the South African Distribution Network Code, utilities are obliged to provide an offer to connect SSEGs under the conditions in the connection application.

Licensing and/or registration requirements shall be in line with the relevant Electricity Regulation Act (ERA) or applicable NERSA requirements as defined in the Grid connection code requirements for renewable power plants (RPPS) connected to the transmission system (TS) or the distribution system (DS) in South Africa and the Grid connection code for battery energy storage facilities (BESF) connected to the transmission system (TS) or the distribution system (DS) in South Africa.

Keywords

embedded generation, parallel operation, utility interface

Contents

This page intentionally left blank

GRID INTERCONNECTION OF EMBEDDED GENERATION

Part 2: Small-Scale embedded generation

Section 1: Utility interface

1 Scope

This section of NRS 097-2 specifies requirements for the utility interface for the interconnection of small-scale embedded generators (SSEGs) to a utility network.

The specification is technology neutral and focusses on the AC side of the power conversion stage of the SSEG that operates in parallel with the utility. Any device that has the the functionality to operate in parallel with the grid may only connect to the grid when it complies fully with the requirements of this document. Specifications for the energy source or energy storage system on the customer side of the installation falls outside the scope of this specification.

The *Grid Connection Code For Renewable Power Plants (RPPS) Connected To The Transmission System (TS) Or The Distribution System (DS) In South Africa* and the *Grid Connection Code For Battery Energy Storage Facilities (BESF) Connected To The Transmission System (TS) Or The Distribution System (DS) In South Africa* define the minimum requirements for any renewable power plant or battery energy storage plant to connect to the grid or network. In this text these documents are referred to as the grid codes. Wherever conflict exists between this set of documents and the grid codes in terms of more strict requirements, the latest versions of the grid codes will take preference.

This utility specification does not guarantee that the respective utilities will allow connection of the SSEG and additional requirements may be set by the utility to ensure safety and quality of supply on the network.

In this part of NRS 097, Section 4 deals with compatibility, Section 5 deals with safety and protection aspects and Section 6 deals with metering. Compatibility aspects are regulated via international standards, industry specifications and licensing conditions, which include relevant parts of the grid codes. In South Africa, safety is regulated via the Occupational Health and Safety Act, calling on amongst others the Electrical Installation Regulations and Electrical Machinery Regulations, which invokes other standards such as SANS 10142-1. The most important safety characteristic of a SSEG installation is the safety disconnect unit, that is integrated into the inverter enclosure of inverter-based systems but is typically installed externally for non-inverter-based systems.

All inverters connected to the South African utility grid shall be type tested against the clauses listed in this document. Some clauses are installation requirements that the installed system shall comply with. These clauses are signified with the words “installation requirements”.

Inverters that are certified in accordance with previous versions of this specification, can still be installed for a period of two years after the publication date of this specification. Certification of inverters after the publication date of this specification shall be done in accordance with this specification. Existing approved installations do not need to be re-approved after the publication of this document.

2 Normative references

The following documents contain provisions which, through reference in this text, constitute provisions of this section of NRS 097-2. All documents are subject to revision and, since any reference to a document is deemed to be a reference to the latest edition of that document, parties to agreements based on this specification are encouraged to take steps to ensure the use of the most recent editions of the documents listed below. Information on currently valid national and international standards can be obtained from the SABS Standards Division.

Grid connection code for renewable power plants (RPPs) connected to the electricity transmission system (TS) or the distribution system (DS) in South Africa, available online, www.nersa.org.za.

Grid connection code for battery energy storage facilities (BESF) connected to the transmission system (TS) or the distribution system (DS) in South Africa, available online, www.nersa.org.za.

SANS 10142-1, *The wiring of premises – Part 1: Low-voltage installations.*

Act No. 85 of 1993 of occupational health and safety act, as amended by, Occupational health and safety amendment act, No. 181 of 1993.

Electrical installation regulations, 2009: Government notice. R: 243, Government gazette, 6 March 2009.

Electrical machinery regulations, 2011: Government notice. R: 250, Government gazette, 25 March 2011.

SANS/IEC 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules.*

SANS/IEC 60947-2, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers.*

SANS/IEC 60947-3, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units.*

SANS/IEC 60947-4-1, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters.*

IEC 61727, *Photovoltaic (PV) systems – Characteristics of the utility interface.*

SANS/IEC 62109-1*, Safety of power converters for use in photovoltaic power systems Part 1: General Requirements.*

SANS/IEC 62109-2*, Safety of power converters for use in photovoltaic power systems Part 2: Particular requirements for inverters.*

IEC 62116:2008, *Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters.*

DIN VDE 0126-1-1, *Automatic disconnection device between a generator and the public low-voltage grid.*

NRS 048-2, *Electricity supply – Quality of supply – Part 2: Voltage characteristics, compatibility levels, limits and assessment methods.*

NRS 048-4, *Electricity supply – Quality of supply – Part 4: Application practices for licensees.*

SANS/IEC 61000-4-7, *Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto*

SANS 211/CISPR 11, *Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement.*

SANS 216-1-1/CISPR 16-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

SANS 216-1-2/CISPR 16-1-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Coupling devices for conducted disturbance measurements*

SANS 216-2-1/CISPR 16-2-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

SANS/IEC 61000-2-2, *Electromagnetic compatibility (EMC) Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

SANS 474:2009/NRS 057, *Code of practice for electricity metering*.

SANS 473:2013/NRS 071, *Automated meter reading for large power users*.

SANS 1186-1, *Symbolic safety signs Part 1: Standard signs and general requirements.*

3 Terms, definitions and abbreviations

For the purposes of this specification, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

alternative supply: power source that serves as an alternative to the main utility supply to the customer loads. Power transfer between the main supply and the alternative supply is done by a break before make switching device

asynchronous generator: induction machine that is accelerated to a speed higher than synchronous speed by means of a mechanical power source on its shaft causing a negative slip and power flow into the supply

bi-direction storage system: storage system with hardware architecture that allows the system to both generate and absorb power from the AC system

customer network: electrical installation downstream of the electricity consumption meter, usually on the customer premises

electromagnetic compatibility: the ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

embedded generator: generation and/or bi-directional storage system embedded in the utility distribution network that operates in parallel with the utility supply

generator size: the maximum apparent power capacity of a generator unit or group of generator units that operates in parallel with the grid in an installation in volt-ampere

hybrid system: in the context of this document a customer installation consisting of a combination of consumption system and/or generation system and/or storage units

hybrid inverter: in the context of this document an inverter with the capability of switching between a supply following operating mode and a supply forming operating mode

installation: the same as “electrical installation” as defined in SANS 10142-1

inverter: power electronic device that converts variable DC or AC to grid compatible AC

island: state in which a portion of the utility or customer network, containing load and generation, continues to operate isolated from the rest of the grid

low voltage: nominal AC voltage levels up to and including 1 kV

parallel operation: both the embedded generator and the utility system supply or absorb power into the same AC system at the same time

power factor: ratio of the active power to the apparent power, measured over the same integrating period

rated current of the equipment: input current of the piece of equipment as declared by the manufacturer and marked as such on the rating plate of the piece of equipment or stated in the product documents

safety disconnection unit: unit that disconnects all phases and neutral of the embedded generator, operating in parallel with the utility network, from the network in response to an out-of-bounds condition

simple separation: separation between electric circuits or between an electric circuit and local earth by means of basic insulation

small-scale embedded generator: embedded generator rated less than 1 MVA

synchronous generator: synchronous machine that operates at a speed which is directly related to system frequency and is capable of operating in isolation from other generating plants

total harmonic distortion: ratio of the sum of the r.m.s. values of the harmonics to the r.m.s. value of the fundamental frequency

unsymmetrical voltage: voltage between any mains conductor (phase or neutral) and the earth [SANS/IEC 61000-2-2]

uninterruptible power supply: power system that comprises an inverter, switchgear, control circuitry and energy storage for maintaining continuity of electricity supply to a load in the case of a disruption of power supply from an electricity distribution network

utility: electricity distribution supply authority (see foreword), in the area of the installation responsible for the electricity network infrastructure

3.2 Abbreviations

AC: alternating current
AMN: artificial mains network
BESF: battery energy storage facility
DC: direct current
LISN: line impedance stabilization network
NEB: neutral to earth bonding unit
PV: photovoltaic
SDU: safety disconnect unit
r.m.s.: root mean square
RPP: renewable power plant
RoCoF: rate of change of frequency
SSEG: small scale embedded generator
THD: total harmonic distortion

4 Utility compatibility

4.1 Voltage, current and frequency

SSEGs shall be able to operate safely under compatibility levels defined in NRS 048-2, unless otherwise stipulated in this document.

4.2 Normal voltage operating range

4.2.1 SSEGs shall not control the voltage, unless agreed to by the utility. Therefore, the voltage operating range for SSEGs is designed as protection, which responds to abnormal utility network conditions and not as a voltage regulation function.

4.2.2 SSEGs shall operate continuously between 85% and 110% of the nominal utility voltage as defined in the grid codes.

4.3 Flicker

Installation requirement: The short-term flicker contribution shall not exceed 0,35 as defined in NRS 048-4 that is also applicable to any other connections as stated in standard connection conditions. Should these flicker levels be exceeded, the customer shall be required to put mitigating measures in place as and when required by the utility.

4.4 DC injection

The average DC current injected by the SSEG shall never exceed 0,5% of the rated AC output current over any 1-minute period.

4.5 Normal frequency operating range

An SSEG that operates in parallel with the utility system shall operate continuously between 47 Hz and 51,5 Hz in accordance with the grid codes.

4.6 Harmonic emissions

4.6.1 The SSEG harmonic and inter-harmonic current distortion shall comply with the relevant emission limits as defined in the grid codes for systems smaller than 5 MW and shown in Table 1.

4.6.2 Total harmonic current distortion shall be less than 5% at rated inverter output.

NOTE The grid codes adopted the limits in Table 1 from IEC 61727. The emission limits from the 35th harmonic and above were obtained by dividing the column 5 limits by 2.

Table 1 — Maximum harmonic current distortion as percentage of rated current

1	2	3	4	5	6
Harmonic order (h)	**h<11**	**11≤h<17**	**17≤h<23**	**23≤h<35**	**35≤h≤50**
Percentage of rated current (Odd harmonics)	4,0	2,0	1,5	0,6	0,3
Percentage of rated current (Even harmonics)	1,0	0,5	0,38	0,15	0,08
Total harmonic current distortion < 5%					
NOTE Even harmonics are limited to 25 % of the odd harmonic limits					

4.7 Power factor

4.7.1 Irrespective of the number of phases to which an SSEG is connected, it shall comply with power factor requirements on each phase for normal system conditions when the output power exceeds 20% of rated active power.

4.7.2 Inverter based SSEGs with nominal power ratings of up to 100 kW shall operate at a power factor of more than 0,98.

4.7.3 Installation requirement: Non-inverter based generator SSEGs with nominal power ratings of up to 100 kW shall operate at a power factor of more than 0,98.

4.7.4 Installation requirement: Asynchronous generator based SSEGs with nominal power ratings of up to 100 kW, which cannot control the power factor in the machine, shall reach a power factor of 0,98 within 60 s and it shall remain above 0,98.

4.7.5 Inverter based SSEGs with nominal power ratings of between 100 kW and 1 MW shall operate at a power factor of more than 0,95.

4.7.6 Installation requirement: Synchronous generator based SSEGs with nominal power ratings of between 100 kW and 1 MW shall operate at a power factor of more than 0,95.

4.7.7 Installation requirement: For asynchronous generator based SSEGs with nominal power ratings between 100 kW and 1 MW, which cannot control the power factor in the machine, the power factor shall reach the value of 0,95 within 60 s and it shall remain above 0,95.

4.8 Synchronization and reconnection

4.8.1 SSEGs shall connect with the utility network only when the voltage and frequency has been stable within the continuous operating ranges provided above for at least 60 seconds.

4.8.2 Installation requirement: Synchronous generator based SSEGs shall synchronize with the utility network before the parallel connection is made.

4.8.3 Installation requirement: Automatic synchronization equipment shall be the only method of synchronization for synchronous generator based SSEGs.

4.8.4 Installation requirement: For synchronous generator based SSEGs, the limits for the synchronizing parameters for each phase are:

a) frequency difference: 0,3 Hz;
b) voltage difference: 5% of nominal voltage per phase; and
c) phase angle difference: 20° (degrees).

4.8.5 Installation requirement: Asynchronous generator based SSEGs do not need to synchronise when the generator is started as a motor before generation starts.

NOTE An asynchronous generator is an induction machine that is accelerated to a speed higher than synchronous speed by means of a mechanical power source on its shaft causing a negative slip and power flow into the supply.

4.8.6 Installation requirement: Asynchronous generator based SSEGs shall be soft started when the start-up voltage change is anticipated to be more than 3%.

4.8.7 The start-up current for inverter based SSEGs shall not exceed the full power rated current of the generator.

NOTE Inverter based SSEGs connect to the utility supply before producing an AC current that is in phase with the utility voltage. This synchronized current typically ramps up from zero amplitude during the start-up process.

4.9 Electromagnetic compatibility (EMC)

4.9.1 All unintentional conducted emissions from generating equipment, in the frequency band 30 kHz to 150 kHz, shall be 9 dBµV lower than the compatibility levels specified in clause 4.12.3 of SANS/IEC 61000-2-2 when measured in unsymmetrical voltage mode (i.e., between any phase or neutral and the earth) using a quasi-peak detector. These voltage emission limits are listed in Table 2.

4.9.2 The test method and set up for verifying compliance shall be according to clause 7 of CISPR 16-2-1. The test receiver used for verification shall comply with clauses 4 and 5 of CISPR 16-1-1 and the AMN or LISN used for verification shall comply with clause 4 of CISPR 16-1-2.

NOTE When measuring conducted emissions at high currents, for example at ≥ 25 A, during testing, the AMN or LISN can be connected as a voltage probe. See clause A.5 in Annexure A of CISPR 16-1-1.

4.9.3 All unintentional conducted emissions from generating equipment, in the frequency band above 150 kHz to 30 MHz, shall comply with SANS 211 (CISPR11), in particular limits for Class A group 1 (< 20 kVA). These voltage emission limits are listed in Table 2.

Table 2 — Conducted emission limits

1	2	3
Frequency range kHz	**Compatibility levels dB(µV)**	**Emission limits dB(µV)**
9 to 30	129,5 to 122[1]	120,5 to 113[1]
30 to 50	122 to 119[1]	113 to 110[1]
50 to 150	113 to 89[1]	104 to 80[1]
150 to 500		79
500 to 5 000		73
5 000 to 30 000		73
NOTE 1 The level decreases linearly with the logarithm of the frequency. NOTE 2 At the transition frequencies, the lower level applies.		

4.9.4 The conducted emission requirement shall be tested on all ports or connections to the utility supply, whether the connection is intended for monitoring, communication, power transfer or any other reason for connecting to the utility supply.

4.9.5 In the event of susceptibility to electromagnetic interference, the unit shall be fail-safe, i.e., any deviation from intended performance must comply with all relevant specifications, both in terms of safety (i.e., disconnection) and impact on the network.

4.9.6 Installation requirement: The owner of the SSEG shall take the necessary remedial action to prevent interference with existing or new ripple-control, building management system equipment or other power line carrier-based communication.

4.9.7 Installation requirement: All radiated emissions from generating equipment shall comply with ICASA requirements.

5 Safety and protection

5.1 General

5.1.1 SSEGs shall not cause safety hazards to people that include the owners (including personnel and inhabitants of the property) of the SSEG, general public, network operators and general emergency response personnel.

5.1.2 SSEGs shall not cause safety hazards to equipment that include utility equipment, other customers' equipment connected to the same network and owners' equipment.

5.2 Safety disconnect unit

NOTE The safety disconnect unit's (SDU) purpose is to protect the installation and the network from personal and equipment safety hazards.

5.2.1 SSEGs shall be equipped with SDUs that separate the SSEGs from the grid due to abnormal conditions for protection of the installation and the network.

5.2.2 Abnormal conditions for inverter based SSEGs shall include network voltage or frequency out-of-bounds conditions, DC current injection threshold exceedance, and residual DC current threshold exceeded.

5.2.3 Abnormal conditions for non-inverter based SSEGs shall include network voltage or frequency out-of-bounds conditions.

5.2.4 Inverter-based SSEGs shall have SDUs in each unit and shall be SANS/IEC 62109-1 and SANS/IEC 62109-2 certified.

5.2.5 Installation requirement: Non-inverter based SSEGs shall be equipped with external electromechanical SDUs with switches that are SANS/IEC 60947-1 and SANS/IEC 60947-4-1 certified.

NOTE Some of the requirements for SDUs in the standards referenced above are listed below to emphasize importance. All applicable requirements in these standards shall be met.

5.2.6 The SDUs shall be able to operate under all operating conditions of the utility network.

5.2.7 A failure within the SDU shall lead to disconnection of the generator from the utility supply and indication of the failure condition.

5.2.8 A single failure within the SDU shall not lead to failure to disconnect. Failures with one common cause shall be taken into account and addressed through adequate redundancy.

5.2.9 The SDU shall disconnect a generator without simple separation, from the network by means of two series connected robust electromechanical switches on each current carrying conductor, including the neutral.

5.2.10 The SDU shall disconnect a generator with simple separation, from the network by means of one series connected robust electromechanical switch on each current carrying conductor, including the neutral.

NOTE The switching unit needs not to disconnect its sensing circuits.

5.2.11 The current breaking capacity of each disconnecting switch shall be rated at the nominal current rating of the inverter.

5.2.12 The total clearance between the inverter AC conductors and the grid conductors when the SDU is switched off, shall be in accordance with SANS/IEC 62109-1 and SANS/IEC 62109-2.

5.2.13 Any programmable parameters of SDU shall be protected from interference by third parties, i.e., password protected or access physically sealed.

NOTE In a hybrid system, the SSEG is allowed to form an intentional island to supply loads after disconnecting from the grid.

5.2.14 Installation requirement: The SDUs of non-inverter based SSEGs shall be equipped with protection relays that are VDE 0126-1-1 certified.

5.2.15 The protection functions and response times in Table 3 shall be applied to all SSEGs.

Table 3 — Protection functions and response times

1	2
Protection function	**Maximum trip time**
V < 50 %	0,2 s
50 % ≤ V < 85 %	10 s
85 % ≤ V ≤ 110 %	Continuous operation
110 % < V < 115 %	40 s
115% ≤ V < 120%	2 s
120 % ≤ V	0,16 s
f < 47 Hz	0,2 s
f > 51,5 Hz	4 s
RoCoF > 1,5 Hz/s	2 s
NOTE It can be assumed that the electromechanical switch will operate within 0,1 s after receiving a signal from the protection relay. The protection function should therefore be set to respond 0,1 s faster than the maximum trip times.	

5.2.16 The permissible tolerance between the setting value and the tripping value is a maximum of ±1% of nominal for the voltage and of ±0,1% of nominal for the frequency.

5.3 Prevention of forming an unintentional island on the utility side

5.3.1 An islanding condition shall cause the SSEG to cease to energize the utility network within 2 s, irrespective of connected loads or other SSEGs.

5.3.2 All inverter based SSEGs shall incorporate passive or active island detection methods.

5.3.3 Islanding detection method of inverter based SSEGs shall be tested according to and must comply with IEC 62116.

5.3.4 Installation requirement: Non inverter based SSEGs shall use the rate of change of frequency (RoCoF) measurement for island detection.

5.3.5 Installation requirement: The RoCoF protection function for non inverter based SSEGs shall be incorporated in the SDU with a trip level of 1,5 Hz/s as listed in Table 3.

5.3.6 The SSEG shall physically disconnect from the utility network in accordance with the requirements of the SDU.

5.4 Neutral to earth bonding when forming an intentional island

5.4.1 To prevent a SSEG neutral connection to the the utility neutral through an earth conductor when the SDU opens, the SSEG shall not have a permanent neutral bonding to earth.

5.4.2 A hybrid system intended to form an intentional island on the load side during utility supply interruption shall open the SDU to prevent unintentional island on the utility side.

5.4.3 Since the SDU opens the neutral on the utility side, the intentional island neutral shall be bonded to earth within 200 ms after the SDU operation using a neutral to earth bonding unit (NEB).

5.4.4 The NEB shall open within a time period of 200 ms before the SDU reconnects the inverter to the utility supply.

5.4.5 The NEB shall consist of an electromechanical switching device rated at the nominal current rating of the inverter.

5.4.6 The total clearance between the inverter neutral and earth conductors when the NEB is switched off, shall be equal the clearance of the SDU in its open state or more.

5.4.7 The NEB shall be an internal inverter component or an external device that is activated by a dedicated control port of the inverter.

5.4.8 The inverter data sheets shall indicate that it contains an internal NEB or a dedicated NEB control port for external devices.

5.4.9 Installation requirement: Inverters equipped with the NEB control port only, shall have external electromechanical NEBs installed that are SANS/IEC 60947-1 and SANS/IEC 60947-4-1 certified.

5.5 DC current injection

Inverter based SSEGs shall open their SDUs within 500 ms if the threshold for DC current injection is exceeded.

5.6 Response to utility recovery

All SSEGs shall respond to utility recovery according to the synchronization and reconnection requirements in Section 4.8.

5.7 Isolation

5.7.1 Installation requirement: As prescribed by SANS 10142-1, each energy source shall have its own, appropriately rated, isolation device. The disconnecting device may be a circuit-breaker with the property of disconnection, or a switch-disconnector.

5.7.2 Installation requirement: The installation shall provide a means of isolating from the utility interface to allow for safe maintenance. The disconnection device shall be a double pole for a single-phase SSEG, a three-pole for a three-phase delta-connected SSEG, and a four-pole for a three-phase star-connected SSEG. The grid supply side shall be wired as the source.

5.7.3 Installation requirement: The breaking capacity of the isolation circuit-breaker closest to the SSEG shall be rated appropriately for the isolation point in accordance with SANS/IEC 60947-2 and SANS/IEC 60947-3. This disconnection device does not need to be accessible to the utility.

5.8 Earthing

5.8.1 Earthing Installation requirements

5.8.1.1 The electrical installation shall be earthed in accordance with SANS 10142-1.

5.8.1.2 Installations with inverter based SSEGs without simple separation shall make use of integrated earth leakage protection able to respond to DC fault currents according to SANS/IEC 62109-2.

5.9 Short-circuit protection

5.9.1 Installation requirement: The SSEG shall have suitably rated short-circuit protection at the connection to the AC mains in accordance with SANS 10142-1.

5.9.2 Installation requirement: The short-circuit characteristics of the SSEG shall be provided to the utility on request.

5.10 Labelling

5.10.1 Installation requirement: A label on the distribution board of the premises where the SSEG is connected shown in Figure 1, shall state: “WARNING: ON-SITE EMBEDDED GENERATION. DO NOT

WORK ON THIS EQUIPMENT UNTIL IT IS ISOLATED FROM BOTH MAINS AND ON-SITE GENERATION SUPPLIES." or similar warning. Disconnection points for all supplies shall be indicated.

5.10.2 Installation requirement: The label shall be permanent with lettering of height at least 8 mm.

5.10.3 Installation requirement: The label shall comply to requirements of SABS 1186-1.

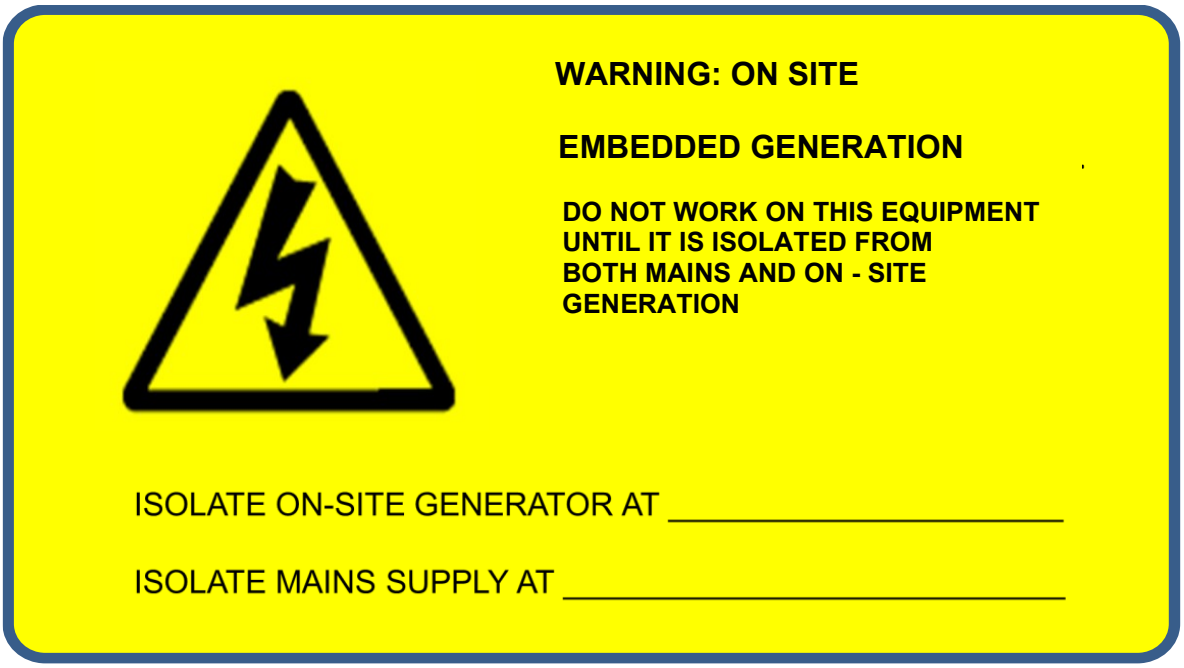

Figure 1 — Example of labelling

6 Metering

6.1 General

6.1.1 Installation requirement: All meters utilized by the utility shall be the property of the utility even when the meters are located on the premises of the customer. Meters that are embedded in the customer's network shall be accessible to the utility on request.

6.1.2 Installation requirement: Metering shall comply to SANS 474/NRS 057 and SANS 473/NRS 071.

6.1.3 Installation requirement: Based on tariff structures defined in NRS 097-2-4, one of the following two metering configurations shall be used:

a) Single-quadrant meter with zero export; and
b) Four-quadrant meter with export.

6.2 Single-quadrant meter

6.2.1 Installation requirement: The installation shall be equipped with a single-quadrant prepaid meter with a single register.

6.2.2 Installation requirement: The SSEG shall have a means of preventing power to flow into the utility supply installed.

6.2.3 Installation requirement: The meter shall record any power that flow into the utility supply as energy consumed.

6.3 Four-quadrant meter

6.3.1 Installation requirement: The installation shall be equipped with a four-quadrant prepaid meter with two registers, one for recording energy consumed and the second for recording energy generated.

6.3.2 Installation requirement: The utility shall process recorded data based on tariff structures defined in NRS 097-2-4.