CITY OF CAPE TOWN		ENERGY DIRECTORATE	
Document Type	**TECHNICAL STANDARD**	Document Number	**EEB 705**
Title	**Standard for the Interconnection of Embedded Generation**	Reference Numbers	
Responsible Section	Engineering: Service Connection Planning Protection	Document Status	**Current**
Technical Reference	Ryno van der Riet	Revision	1
		Review Date	Feb 2023
Compiled	Ryno van der Riet Digitally signed by Ryno van der Riet Date: 2022.02.10 10:45:10 +02'00' Ryno van der Riet (Head: Protection and Telecoms)		
Supported	Manager: Engineering	Edgar Capes Digitally signed by Edgar Capes DN: cn=Edgar Capes, o=City of Cape Town, ou=Electricity Generation & Distribution, email=edgar.capes@capetown.gov.za, c=ZA Date: 2022.02.10 11:39:49 +02'00'	
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Contents

1 OBJECTIVE

This standard sets out the minimum technical and statutory requirements for the interconnection of embedded generators (EG) operated in parallel with the City of Cape Town's (CCT) electrical networks. This standard serves to fulfil the Distributor's obligation in terms of the South African Distribution Code - Network Code (SADCNC).

2 SCOPE

This document applies to systems where the generating plant may be paralleled with the CCT's network permanently, periodically or temporarily.

The scope of the document is limited to the technical requirements that must be adhered to for EG installations that will be connected to the City's grid and the operating parameters associated with running the plant. The network isolation and switching requirements for safe operations are specified in the applicable SANS and City of Cape Town procedures.

For generating plant that does not operate in parallel with the Distribution grid e.g. own use customer generators off-grid or stand-by generators, where momentary synchronism (< 2 minutes) is required and not break before make, the Standard for Standby Supply Soft Load Transfer (SLT) Scheme, document EEB 317 shall apply. Any standby generator that is not a SLT scheme and operates in parallel with the grid, shall comply with this standard.

The standard provides for generic interconnection requirements and shall be applicable to all different types of generators, prime movers, etc. In certain cases, (e.g. wind generating technology) it might be necessary to supplement the requirements of this standard with additional technology-specific requirements.

This standard is in anticipation of the proposed NRS 097-1: Code of Practice for the interconnection of embedded generation to electricity distribution networks: Part 1 MV and HV, applicable for Category A3, B and C Renewable Power Plants (RPPs).

This standard specifically addresses the practical utility interconnection scenarios for EG systems meeting the requirements of NRS 097-2: Grid interconnection of embedded generation: Part 2 Small scale embedded generation, proposed NRS 097-1 and all other applicable standards and South African Grid Codes.

3 REFERENCE / RELATED DOCUMENTS

The following documents contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the references indicated were valid. Information on currently valid national and international standards and specifications can be obtained from the SABS.

Where any discrepancy exists between the NRS standards and these requirements, these requirements and the SAGC's take precedence unless amended in writing by the CCT. The technical requirements for all related grid infrastructure shall be as per the CCT specified technical standards that can be provided on application.

Parties using this standard shall apply the most recent edition of the documents listed below:

3.1 Normative references

Identifier	Title
South African Legislation:	Electricity Regulation Act, 2006 (Act No 4 of 2006). Occupational Health and Safety Act, 1993 (Act No 85 of 1993. South African Distribution Code (all parts). South African Transmission Grid Code (all parts). Grid Connection Code for Renewable Power Plants (RPPs) connected to the electricity Transmission System (TS) or the Distribution System (DS) in South Africa Grid Connection Code for Battery Energy Storage Facilities (BESF) connected to the electricity Transmission System (TS) or the Distribution System (DS) in South Africa (once promulgated)
International and National Standards	IEC 60870-5-101, Telecontrol equipment and systems – Transmission protocols – Companion standard for basic Telecontrol tasks IEC 60870-5-104, Telecontrol equipment and systems – Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles IEC 61683, Photovoltaic systems - Power conditioners - Procedure for measuring efficiency IEC 61727, Photovoltaic (PV) systems - Characteristics of the utility interface IEC 62116, Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures IEC 62920, Photovoltaic power generating systems - EMC requirements and test methods for power conversion equipment IEEE 1547, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems. IEEE 1547.1, IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems. IEEE 1815-2012, Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3). NRS 029, Current transformers for rated AC voltages from 3,6kV up to and including 420kV. NRS 030, Electricity distribution – Inductive voltage transformers for rated AC voltages from 3,6kV up to and including 145kV for indoor and outdoor applications. NRS 031, Alternating Current disconnectors and earthing switches (above 1000V). NRS 037-1, Telecontrol Protocol for stand-alone remote terminal units. NRS 047, Electricity Supply – Quality of service and reporting guidelines 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 guidelines for utilities.

	NRS 048-6, Electricity Supply – Quality of Supply Part 6: Measurement and reporting of medium-voltage network interruption performance NRS 048-8, Electricity Supply – Quality of Supply Part 8: Measurement and reporting of extra high voltage (EHV) and high voltage (HV) network interruption performance NRS 048-9, Electricity Supply – Quality of Supply Part 9: Code of Practice –Load reduction practices, system restoration practices and critical load and essential load requirements under power system emergencies. NRS 054, Rationalized User Specification – Power Transformers. NRS 058, Cost of supply methodology for application in the electrical distribution industry NRS 069, Guideline for distribution connection charges for loads NRS 076, Earthing of distribution substations with nominal voltages up to and including 132 kV NRS 082, Recommended maintenance policy for electricity networks NRS 097-1 Code of Practice for the interconnection of embedded generation to electricity distribution networks: Part 1 MV and HV (once published) NRS 097-2-1: Grid interconnection of embedded generation: Part 2 Small scale embedded generation Section 1: Utility interface NRS 097-2-3 Grid interconnection of embedded generation: Part 2 Small scale embedded generation Section 3: Simplified utility connection criteria for low-voltage connected generators SANS 211 / CISPR 11 Industrial, scientific and medical equipment — Radio-frequency disturbance characteristics — Limits and methods of measurement SANS 222 (CISPR 22), Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement. SANS 473 Automated meter reading for large power users (previous NRS 071) SANS 474 Electricity metering - Standard requirements (previous NRS 057) SANS 725, IEEE guide for safety in a.c. substation grounding SANS 1019, Standard voltages, currents and insulation levels for electricity supply. SANS 8894: Dead-grid safety lock [under development] SANS 10142-1 The wiring of premises Part 1: Low-voltage installations SANS 10142-1-2 The wiring of premises – Part 1-2: Additional special requirements for low voltage small scale embedded generation installations connected in parallel to the normal electricity supply [under development] SANS 10142-2 The wiring of premises Part 2: Medium-voltage installations above 1 kV AC not exceeding 22 kV AC and up to and including 3 MVA installed capacity SANS 10200, Neutral earthing in medium voltage industrial power systems. SANS 60050-441 International electrotechnical vocabulary Chapter 441: Switchgear, control gear and fuses

	SANS 60076 suite (e.g. Parts 1, 2, 3, 4, 5 and 7), Power transformers SANS 60364-7-712, Low voltage electrical installations: Part 7-712: Requirements for special installations or locations — Solar photovoltaic (PV) power supply systems SANS 60529, Degrees of protection provided by enclosures (IP Code). SANS 61000 suite (e.g. Parts 1 to 6), Electromagnetic compatibility (EMC) SANS 61243 suite (e.g. Parts 1, 2, 3, and 5), Live working — Voltage detectors SANS 61936-1, Power installations exceeding 1 kV a.c. Part 1: Common rules SANS 62103, Electronic equipment for use in power installations SANS 62109 suite (e.g. Parts 1, 2 and 3), Safety of power converters for use in photovoltaic power systems SANS 62271 suite (e.g. Parts 100, 101, 102, 103, 105, 106, 112, 200, 201, 202, 203 and 211), High-voltage switchgear and control gear
International and National Standards (protection relays)	IEC 60068-2-1, Environmental testing — Part 1 Cold. IEC 60068-2-2, Environmental testing — Part 2 Dry Heat. IEC 60068-2-30, Environmental testing — Part 30 Damp heat, cyclic (12h + 12h cycle). IEC 60255-30, Electrical relays Part 3: Single input energizing quantity measuring relays with dependent and independent time. IEC 60255-6, Electrical relays Part 6: Measuring relays and protection equipment. IEC 60255-21, Electrical relays Part 21 Vibration, shock, bump and seismic tests on measuring relays and protection equipment (All sections). IEC 60255-22, Electrical relays Part 22 Electrical disturbance tests for measuring relays and protection equipment (All sections). IEC 60255-30, Electrical relays Part 3: Single input energizing quantity measuring relays with dependent and independent time.
Other Standards	Eskom 240-61268576 Standard for the interconnection of embedded generation Eskom 240-126260252 The dead-grid safety lock specification and minimum requirements for LV connected photovoltaic embedded generators
Other Documents	CCT SSEG requirements document: EBZA33 City of Cape Town – Electricity Supply By-law EEB 317 - City of Cape Town Standard for standby supply soft load transfer scheme CCT QoS Specification, Operation Procedure Manual, Grid Connection Equipment and DUoS (Status: Under development)

3.2 Informative references

International	VDE-AR-N 4105, Power Generating Plants in the Low Voltage Network

4 DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

Asynchronous generator: Induction generator: type of rotating electrical generator that operates at a speed not directly related to system frequency, the machine of which is designed to be operated in parallel with a network that contains other generation as the output voltage, and frequency is determined by the system to which it is connected
NOTE: A mains-excited asynchronous generator will cease generation on disconnection of the parallel connection. Power-factor corrected and self-excited asynchronous generators are derivatives of the mains-excited generator. (NRS097-2-1)

Circuit breaker: A mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short circuit. (SANS 60050-441). This excludes any ring main units with circuit breaking capacity.

Co-generator: source of electrical power that complies with types I, II or III below:

- Type I: Projects utilizing process energy which would otherwise be underutilized or wasted (e.g. waste heat recovery).
- Type II: Primary fuel based generation projects which produce, as part of their core design, other usable energy in addition to electricity (e.g. Combined Heat and Power projects).
- Type III: Renewable fuel based projects where the renewable fuel source is both the primary source of energy, and is a co-product of an industrial process (e.g. use of bagasse and/or forestry waste from the sugar and paper industries).

Control gear: A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for the control of electric energy consuming equipment. (SANS 60050-441)

Disconnector: A mechanical switching device which provides, in the open position, an isolating distance in accordance with the specified requirements. Note: A disconnector is capable of opening and closing a circuit when either negligible current is broken or made or when no significant change in the voltage across the terminals of each of the poles of the disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying for the specified time currents under abnormal conditions such as those of short circuit. (SANS 60050-441)

Distributor: A legal entity that owns or operates/distributes electricity through a distribution system. [SAGC]

Distribution System: An electricity network consisting of assets operated at a nominal voltage of 132 kV or less. [SAGC]

Distribution Use-of-System (DUoS): Agreement for an embedded generator to be connected to the network of the distributor.

DNP3: (Distributed Network Protocol) is the preferred communications protocol used for the control of electricity on transmission and distribution networks as in NRS 037-1

Earthing switch: A mechanical switching device for earthing parts of a circuit, capable of withstanding for a specified time currents under abnormal conditions such as those of short circuit, but not required to carry current under abnormal conditions of the circuit. Note: An earthing switch may have a short circuit making capacity. (SANS 60050-441)

Embedded generator's authorized person: person appointed by the embedded generator in terms of the appropriate act to sanction the return to service of plant after major maintenance or repair

Embedded generator's responsible person: person appointed by the embedded generator in terms of the appropriate act to receive communications and take necessary action in accordance with instructions from the system controller

Embedded generation: A power generation plant using renewable power plant primary renewable energy sources or fuel driven energy sources that is grid-tied.

Embedded generator: A legal entity that operates one or more unit(s) that is connected to the Distribution System. Alternatively a legal entity that desires to connect one or more unit(s) to the Distribution System (SAGC).
NOTE: This definition includes all types of connected generation, including co-generators and renewables. Alternatively, the item of generating plant that is or will be connected to the distribution network.

Fuse-combination unit: A combination of a mechanical switching device and one or more fuses in a composite unit, assembled by the manufacturer or in accordance with his instructions. Note: Some fuse-combination units may be provided with a striker release such that the operation of any striker causes all poles of the associated mechanical switching devices to open. (SANS 60050-441)

High voltage: nominal voltage levels greater than 44 000V and up to and including 220 000V [SANS 1019]

Indoor switchgear and control gear: Switchgear and control gear designed solely for the installation within a building or other housing, where the switchgear and control gear is protected against wind, rain, snow, abnormal dirt deposits, abnormal condensation, ice and hoar frost (SANS 60050-441)

Islanding: The opening of a circuit breaker or circuit breakers resulting in the severance of the synchronous connection between the Network Service Provider's network and the Embedded Generator, or between the Network Service Provider's network

Loss-of-grid protection: relay protection designed to detect the loss of connection to the utility network and trip the embedded generator to prevent it from energizing an island.

Low voltage: nominal voltage levels up to and including 1kV [SANS 1019]

Mains-excited asynchronous generator: A type of rotating electrical generator which operates at a speed not directly related to system frequency. The machine is designed to be operated in parallel with a network containing other generation. The machine is excited by reactive power drawn only from the network to which it is connected. The output voltage and frequency are determined by those of the system to which it is connected. On disconnection of the parallel connection, the mains-excited asynchronous generator will cease generation. (Eskom 240-61268576)

Medium voltage: nominal voltage levels greater than 1 000V and up to and including 44 000V [SANS 1019]

Metal-enclosed switchgear and control gear: Switchgear and control gear assemblies with an external metal enclosure intended to be earthed, and complete except for external connections. Note: This term generally applies to high voltage switchgear and control gear. (SANS 60050-441)

Network Service Provider (NSP): A legal entity that is licensed to provide network services through the ownership and maintenance of an electricity network (SAGC).

Outdoor switchgear and control gear: Switchgear and control gear suitable for installation in the open air, i.e. capable of withstanding wind, rain, snow, dirt deposits, condensation, ice and hoar frost. (SANS 60050-441).

Point of common coupling (PCC): The point in a network where more than one customer is connected or will be connected (NRS 000-1: 2008). The electrical node where more than one customer is connected (SAGC).

Point of connection (POC) The electrical node(s) on the Network Service Provider's network where the Embedded Generator's electrical equipment is physically connected to the Network Service Provider's electrical equipment. (Eskom definition in document 240-61268576)**.** The electrical node on a distribution system where a customer's assets are physically connected to the Distributor's assets (SAGC).

Point of Control: The point at which the electrical installation on or in any premises can be switched off by a user or lessor from the electricity supplied from the point of supply [Regulation R1, OHS Act] NRS 000-1:2008. The point at which an electrical installation on or in any premises can be switched off by a user or lessor from the electricity supplied from the point of supply, or the point at which a particular part of an electrical installation on or in any premises can be switched off where different users occupy different portions of such premises.
Shared network charge (EGD SNC) policy.

Point of supply (POS): The physical point on the electrical network, where electricity is supplied to a customer or where the customer's network connects to that of the utility (NRS 000-1:2008). The point determined by the service provider at which the service provider supplies electricity to any premises. This is normally the point on the boundary of the property at which electricity is supplied to the property (EGD SNC policy). Physical point on the electrical network where electricity is supplied to a customer (SAGC).

Point of generator connection (PGC): The circuit-breaker and associated ancillary equipment (instrument transformers, protection, isolators) that connects a generator to any electrical network. Where more than one such circuit-breaker exists, the PGC shall be the circuit-breaker electrically closest to the generator.

Point of utility coupling (PUC):
The circuit-breaker that connects the embedded generator facility to the distribution network.
NOTE: This could include associated ancillary equipment (instrument transformers, protection, isolators). The PUC forms the point of demarcation between the assets of the distributor, and those of the embedded generator. The PUC may be located near the Point of Control or may be

some other point(s) within the Embedded Generator's facility between the PGC and Point of Control. The PUC and POS can be the same i.e. the point at which the utility infrastructure is connected to the consumer's network and responsibility is then transferred from one party to the other for ownership and maintenance.

Point of Secure Supply (PSS): That point on the Network Service Provider's network at which a single upstream contingency will not result in the islanding of an Embedded Generator with a portion of the supply network.

Power factor corrected asynchronous generator: A derivative of the mains-excited asynchronous generator where the machine is excited partly by the network to which it is connected and partly by a device of fixed capacitance connected locally to the machine. On disconnection of the parallel connection, the power factor corrected asynchronous generator may continue to generate electrical power at a voltage and frequency determined by the machine and system characteristics. (Eskom 240-61268576)

Renewable Power Plant (RPP): A unit or a system of generating units producing electricity based on a primary renewable energy source e.g. wind, sun, water, biomass, etc. A RPP can use different kinds of primary energy sources. If a RPP consists of a homogenous type of generating units, it can be named as follows [RSA Grid Code Requirements for Renewable Power Plants]:

- **PV Power Plant (PVPP):** A single photovoltaic panel or a group of several photovoltaic panels with associated equipment operating as a power plant.
- **Concentrated Solar Power Plant (CSPP):** A group of aggregates to concentrate the solar radiation and convert the concentrated power to drive a turbine or a group of several turbines with associated equipment operating as a power plant.
- **Small Hydro Power Plant (SHPP):** A single hydraulic driven turbine or a group of several hydraulic driven turbines with associated equipment operating as a power plant.
- **Landfill Gas Power Plant (LGPP):** A single turbine or a group of several turbines driven by landfill gas with associated equipment operating as a power plant.
- **Biomass Power Plant (BMPP):** A single turbine or a group of several turbines driven by biomass as fuel with associated equipment operating as a power plant.
- **Biogas Power Plant (BGPP):** A single turbine or a group of several turbines driven by biogas as fuel with associated equipment operating as a power plant.
- **Wind Power Plant (WPP):** A single turbine or a group of several turbines driven by wind as fuel with associated equipment operating as a power plant. This is also referred to as a wind energy facility (WEF).

Renewable Power Plant (RPP) Categories: Renewable power plants are grouped into the following three categories [GCRPP]:

- **Category A:** 0 – 1 MVA, This category includes RPPs with rated power of less than 1 MVA and connected to the LV voltage (typically called 'small or micro turbines'). This category shall further be divided into 3 sub-categories:
  (i) Category A1: This sub-category includes RPPs of Category A with rated power in the range of 0 to 13.8 kVA.
  (ii) Category A2: This sub-category includes RPPs of Category A with rated power in the range greater than 13.8 kVA but less than 100 kVA.
  (iii) Category A3: This sub-category includes RPPs of Category A with rated power in the range 100 kVA but less than 1 MVA.
  Note: For RPPs connected to multi-phase supplies (two- or three-phase connection at the POC), the difference in installed capacity between phases may not exceed 4.6 kVA per phase.

- **Category B:** 1 MVA – 20 MVA
  This category includes RPPs with rated power in the range equal or greater than 1 MVA but less 20 MVA.
  Note: GCBESF has additional categories, i.e. B1 ≥1 MW to < 5 MW and B2 ≥ 5 MW to < 20 MW)
- **Category C:** 20 MVA or higher
  This category includes RPPs with rated power equal to or greater than 20 MVA.

Ring main unit: switchgear assembly with an external metal enclosure, usually comprising two ring main switches connected in series and a switch, switch-fuse, or switch with circuit breaking capacity connected to the junction between the ring main switches. (NRS 000-1: 2008 Ed 1)

Self-excited asynchronous generator: A derivative of the mains-excited asynchronous generator where the machine is excited purely by a device of variable capacitance connected locally to the machine. The machine is capable of operation in isolation from a network containing other generation and in this respect is similar to the synchronous generator. Under certain conditions, the self-excited asynchronous generator may be operated in parallel with other generation, and on failure of that connection, the machine will continue to generate at a voltage and frequency determined by its control equipment. (Eskom 240-61268576)

Soft load transfer (SLT): A system for a stand-by supply that needs momentary synchronisation/paralleling with the City's distribution network prior to operating the automatic transfer switch (ATS) when the City's supply is restored and vice versa, to allow a seamless transfer of supply to customer loads.

Stand-by generator: legal entity that operates or desires to operate a generating plant so as to provide a stand-by supply in the event of a loss of the grid electricity supply
NOTE: The stand-by generator's plant will only be connected to the CCT's network for maintenance load testing, and only if the requirements of this code of practice have been fulfilled.

Substation (of a power system): part of a power system, concentrated in a given place, including mainly the terminations of transmission or distribution lines, switchgear and housing and which may also include transformers. It generally includes facilities necessary for system security and control (e.g. the protective devices) [IEC]

Switchgear: A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for the use in connection with generation, transmission, distribution and conversion of electrical energy. (SANS 60050-441)

Switchgear and control gear: A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures. (SANS 60050-441)

Switch disconnector: A switch which, in the open position, satisfies the isolating requirements specified for a disconnector. (SANS 60050-441)

Switch [disconnector] [switch-disconnector] fuse: A switch [disconnector] [switch-disconnector] in which one or more poles have a fuse in series in a composite unit. (SANS 60050-441)

Switch [mechanical]: A mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions which may include specified operating conditions and also carrying for a specified time currents under specified abnormal conditions such as those under short circuit. Note: A switch may be capable of making but not breaking short circuit currents. (SANS 60050-441)

Synch-check: Synchro-check relay/function that electrically determines if the difference in voltage magnitude, frequency and phase angle falls within allowable limits. Synch check allows the closing conditions of a circuit breaker to be checked by inhibiting the closing circuit until approach of the correct synchronising conditions

Synchronising: The process of manually (synchroscope etc.) or automatically (synchronising unit) controlling generation equipment to attain the conditions where the voltage magnitudes, frequency and phase angle differences, of two independent electrical systems, fall within allowable limits so as to initiate an interconnection between the two electrical systems.

Synchronous generator: A type of rotating electrical generator which operates at a speed that is directly related to system frequency. The machine is designed to be capable of operation in isolation from other generating plants. The output voltage, frequency and power factor are determined by control equipment associated with the generator. Under certain conditions, the synchronous generator may be paralleled with a network containing other generation. On disconnection of the paralleled connection, the synchronous generator will continue to generate at a voltage and frequency determined by its control equipment. (Eskom 240-61268576)

System Operator (SO): The legal entity licensed to be responsible for short-term reliability of the Interconnected Power System, which is in charge of controlling and operating the Transmission System and dispatching generation (or balancing the supply and demand) in real time. (SAGC).

System controller: person on shift at the CCT's or System Operator's Control Centre.

Thermal Generating Unit: A generating unit that uses heat (for instance the burning of fossil fuels) to generate electricity (either through steam or internal combustion processes). This shall include coal, concentrated solar power, nuclear and gas turbine units [SAGC: The Scheduling and Dispatch Rules].

Transmission System (TS): The TS consists of all lines and substation equipment where the nominal voltage is above 132 kV. All other equipment operating at lower voltages are either part of the Distribution System or classified as transmission transformation equipment. (SAGC)

Transmission Network Service Provider (TNSP): A legal entity that is licensed to own and maintain a network on the Transmission System (SAGC).

Utility lockable switch: A 24/7 accessible disconnector to the utility associated with the embedded generator source isolation that has an isolating switch with an utility shackle padlock function.

4.2 Abbreviations

AC: alternating current
ARC: auto reclose
BESF: Battery energy storage facility
CB: circuit-breaker
CCT: City of Cape Town
CDD: central disconnect device
CoC: Certificate of Compliance
CT: current transformer
DC: direct current
DGSL: dead grid safety lock
DUoS: Distribution Use-of-System
GCBESF: Grid connection code for battery energy storage facilities connected to the electricity transmission or distribution system in South Africa
GCRPP: Grid connection code for renewable power plants connected to the electricity transmission or distribution system in South Africa
EG: embedded generator
EGD: Electricity Generation and Distribution
EIR: Electrical Installation Regulations
EMT: electromagnetic transient
ERA: Electricity Regulation Act
HV: high voltage
LV: low voltage
MCOV: maximum continuous over voltage
MFMA: Municipal Finance Management Act
MV: medium voltage
NEC/R: neutral earthing compensator with resistor
NSP: Network Service Provider
NERSA: National Energy Regulator of South Africa
NTC: National Transmission Company
PCC: point of common coupling
PGC: point of generator connection
POC: Point of Connection
POD: Point of delivery
POS: Point of supply
PSS: point of secure supply
pu: per unit
PUC: point of utility coupling
QOS: quality of supply
SADCNC: South African Distribution Code: Network Code
SAGC: South African Grid Code
SATGCNC: South African Transmission Grid Code: Network Code
SCADA: supervisory control and data acquisition
SEF: sensitive earth fault
SLT: soft load transfer
SNC: shared network charge
SO: System operator
SSP: secure supply point
SSEG: Small Scale Embedded Generation
TNSP: Transmission Network Service Provider
TS: Transmission system
ROCOF: rate of change of frequency (protection)
RPP: Renewable Power Plant
RTU: remote terminal unit
VT: voltage transformer

5 BACKGROUND

The City adopted NRS 097-2-1 for low voltage EG power plants up to 1 MVA and the Eskom standard 240-61268576 for medium voltage and high voltage EG power plants in the absence of NRS 097-1.

Utility interface solutions require compliance with the above documents and must also be compliant to Section 8.4: Connection Point Technical Requirements of the South African Distribution Code: Network Code (SADCNC) that states the following:

(1) The *Embedded Generator* shall be responsible for the design, construction, maintenance and operation of the equipment on the generation side of the *connection point*.
(2) The *Embedded Generator* shall be responsible for the provision of the site required for the Installation of the *CCT* equipment required for connecting the generating facility.
(3) The technical specifications of the connection shall be agreed upon by the participants based on The *Distribution System* Impact Assessment Studies.
(4) A circuit breaker and visible isolation shall be installed at the *connection point* to provide the means of electrically isolating the *Distribution System* from the generating facility.
(5) The *Embedded Generator* shall be responsible for the circuit breaker to connect and disconnect the generator.
(6) The location of the circuit breaker and visible isolation shall be decided upon by the *participants*.
(7) The *Embedded Generator* shall pay for any expenses incurred by the *CCT* on behalf of the *Embedded Generator* in line with the Tariff Code

This standard addresses the different scenarios meeting the above whilst supplied from the utility by means of low voltage or medium voltage. EG power plant is mostly installed deep into the customer’s low voltage network and must have specific protection, safety and quality of supply (QoS) systems installed and commissioned ensuring the optimal operation of the generation plant in synchronism with the utility. Most important is the protection that must be dead-line detection compatible to prevent the EG power plant from being connected to the de-energised City network. QoS and signal and control equipment must be robust.

Technical solutions are specified for the isolation/disconnection devices that will meet the above specifications that cannot provide visible isolation by means of providing two in series isolation/disconnection devices in terms of the SADCNC.

6 LEGAL REQUIREMENTS

The Electricity Regulation Act 4 of 2006 and Regulations as amended thereto shall apply for the legislative requirements with regard to the generation, transmission, distribution, licence, registration, exemption and trading of electricity under the Act.

Section 47 (1) of the Act makes provision for the Regulator to, following consultation with licensees and other participants, set guidelines and publish codes of conduct and practice. The South African Grid Code, Grid Code Requirements for Renewable Power Plants, Distribution Code and the Battery Energy Facility Storage Grid Code are examples of such codes of practice.

The South African Distribution Code includes a section of specific requirements for the connection of EG power plants. The SADCNC (Section 8.4.1.1 (1)) requires that all EG power plants of nominal capacity greater than 10 MVA shall in addition to the other requirements of the Distribution Codes, also comply with the protection requirements of Section 3.1 of the South African Transmission Grid Code: Network Code (SATGCNC).

The South African Grid Code Requirements for Renewable Power Plants takes precedence whenever there is a conflict between it and the other Codes.

City of Cape Town Electricity Supply By-law applies.

7 OPERATIONAL AND SAFETY ASPECTS

The EG must obtain from the City a written agreement to operate the generating facility in parallel with its network. ERA, Schedule 2 generation licencing or registration of the EG applies.

GCRPP, GCBESF and NRS 048 generation compliance studies are required by the EG inclusive of electromagnetic transient (EMT) simulation using appropriate software. The EG shall obtain approval from the System Operator by demonstrating SAGC compliance.

Grid engineering studies will be done by the City for the proposed EG facility.

Distribution Use-of-System (DUoS) requirements within scope of this technical specification includes the RPP data exchange by both the distributor and the RPP embedded generator technical data in terms of SAGC for the First Stage. A DUoS letter will be issued by the distributor to the embedded generator in support for their NERSA generation application after extensive generation and grid engineering studies. Electrical dynamic simulation models are required for SAGC Stages 2 and 3. A DUoS Agreement for connection to the distribution grid or wheeling for the purpose of own use of exporting energy from the embedded generator is separate to this technical specification that includes:

- The Agreement;
- Charges;
- Charge security, where required;
- Operating Procedure Manual for the engineering, commissioning, maintenance and operation of the embedded generator;
- Infrastructure Connection Equipment;
- Quality of Supply Specification;
- Supplementary Supply Agreement.

The above documents will be part of the approval process. It should include details of ownership, testing, commissioning, operation, maintenance and the control of substation and generation plant between both parties (i.e. the EG and the City). The schedule shall include:

a) Names and contact details of responsible and OHS Act General Machinery
b) Regulations (GMR) 2.1 competent persons and the City's staff names and contact details.
c) A description of any operating limitations with regard to the plant and/or the interconnection.

The EG shall ensure that all operating personnel are competent in that they have adequate knowledge and sound judgment to take the correct action when dealing with an emergency. Failure to take correct action may jeopardize the EG power plant's installation and/or the City's network. EGs shall ensure that:

a) Except in the case of agreed unmanned facilities, the responsible and GMR 2.1 competent persons are available at all times to receive communications from the City's Network Control Centre so that emergencies requiring urgent action by the EG can be dealt with adequately. Where required by the City, it will also be a duty of the EG's staff to advise the City's Control Centre immediately of any abnormalities that occur on the EG plant which have caused, or might cause, disturbance to the Network Service Provider's network;
b) In the case of unmanned facilities, the Network Service Provider will have remote Control facilities to trip and isolate the facility at the EG feeder circuit breaker or if not available, at the PUC. The City shall not control the PGC circuit breaker / isolation devices directly.

c) Where it is necessary for EG employees to operate City's network equipment (where provided), they have been designated in writing by the City as an 'Appointed Authorised Operator' for this purpose. All operations on the City equipment must be carried out to the specific instructions of the City's Network Control Centre. In an emergency, a switch can be opened by anybody, without prior agreement in order to avoid danger. The operation must be reported to the City Network Control Centre immediately afterwards.

The EG shall maintain and operate their plant and equipment in terms SO requirements and NERSA License and compliance with the mandatory reporting to NERSA is required as per the Electricity Regulation Act promulgation.

Compliance with the OHS Act is required at all times.

For SSEG, requirements of NRS 097- 2 apply.

NRS 097-1 will apply, once published.

8 TECHNICAL DETAIL

8.1 Low Voltage Embedded Generation under 1 MVA

NRS 097-2-1 and NRS 097-2-3 are published for grid interconnection of embedded generation (less than 1 MVA) at low voltage and is adopted by the City of Cape Town as the normative standard for grid-tied EG.

The approval process for small-scale embedded generation (SSEG) installations in the City varies depending on the size of the system and customer category. The details are described in the City's SSEG Requirement document and NRS 097-2 All Parts (1 and 3 published, 4 under development) and all SSEG applications less than 1 MVA must comply with conditions and process described therein.

8.1.1 Requirements

The scenarios below are applicable.

8.1.1.1 Small Scale Embedded Generation LV connected category A1

All EG power plants grid-tied without storage and grid-tied hybrid with storage shall be compliant to NRS 097-2-1.

Refer to attached drawings SK 5276 Sheets 2 and 3 respectively.

Note: SANS 8894 and SANS 10142-1-2 that are under development, must be complied with when published. An alternative to the DGSL, is an utility accessible lockable switch.

8.1.1.2 Embedded Generation for category A2/A3 with POC connected at LV or MV above 30 kVA and under 1 MVA with central disconnect devices (CDD)

Point of control is at LV or MV and the low voltage EG power plant is deep into the customer LV network. Out of bounds conditions is sensed closest to the point of control to operate the decentralised central disconnecting isolation devices that will provide the function of the SADCNC, Section 8.4(4) that requires: "a circuit breaker and visible isolation shall be installed at the connection point to provide the means of electrically isolating the Distribution System from the generating facility". This functionality will be achieved by means of the CDD.

All EG power plants larger than 30 kVA shall have a central disconnect device for more than one inverter in terms of NRS 097-2-1: Alternative to CDD is the DGSL, specified below or an utility accessible lockable switch.

Refer to attached drawing SK5276 Sheet 6.

When any out of bound condition occurs, secure fail safe operation shall be ensured by utilizing hard (copper) wiring, suitably sized two in series disconnectors/isolators and type tested grid protection relay. This system shall detect any loss of grid, abnormal system voltage and frequency conditions. See section 8.2.2.11.6.

GCRPP control and signal for Category A3 shall make use of
IEEE 1815-2012 (DNP 3) or IEC 60870-5-104 protocols for SCADA communication with CCT. All protocol conversion tools or software shall ensure the inverters of the EG plant complies with the signals and controls defined in GCRPP. Refer to Appendix B for the SCADA interface detail in SSEG Cat A3 PLANT DNP3_SCADA_INTERFACE and SSEG Cat A3 PLANT IEC*-104 / 101 SCADA_INTERFACE.

<u>Router requirements:</u>
The router which will be used to connect the CCT's peering environment shall comply, but is not limited to the requirements below:

- Routing:
    - Default routing – Layer 3 functionality
    - Direct connect Network/Interface functionality

- Security:
    - IPSEC – SHA 2
    - AES – 256
    - PSK – Not Clear text
    - HMAC
    - IKE
    - ACL, Source/Destination – Encryption Domain
    - SA – IP authentication

- Default settings:
    - DHCP
    - NAT
    - SNMP

- Authentication:
    - AD, Radius etc.

- SSI Encryption:
    - Preferably tls1.2

8.1.1.3 Embedded Generation for category A2/A3 LV or MV connected above 30 kVA and under 1 MVA with dead grid safety lock (DGSL)

The DGSL shall be installed in the EG power plant to ensure that it is not possible for the EG to energise a portion of the Utilities network and consequently create a hazard to the staff and public to meet the SADCNC, Section 8.4(4) requirements. The DGSL shall be installed in terms of SANS 10142-1-2 and comply with SANS 8894 or Eskom 240-126260252 and have a valid Conformance Certificate for the DGSL (Alternatively, all the individual DGSL components shall comply with SANS 10142-1 Section 4: Compliance and Applicable Standards suited for the EG size and meet all the Eskom 240-126260252, Section 6: DGSL requirements).

Alternative to the DGSL, is a utility accessible lockable switch.

Note: SANS 8894 and SANS 10142-1-2 that are under development, must be complied with when published.

Refer to attached drawing SK5276 Sheet 7.

GCRPP control and signal for Category A3 shall make use of
IEEE 1815-2012 (DNP 3) or IEC 60870-5-104 protocols for SCADA communication with CCT. All protocol conversion tools or software shall ensure the inverters of the EG plant complies with the signals and controls defined in GCRPP. Refer to Appendix B for the SCADA interface detail in SSEG Cat A3 PLANT DNP3_SCADA_INTERFACE and SSEG Cat A3 PLANT IEC*-104 / 101 SCADA_INTERFACE.

Router requirements:
The router which will be used to connect the CCT's peering environment shall comply, but is not limited to the requirements below:

- Routing:
  - Default routing – Layer 3 functionality
  - Direct connect Network/Interface functionality

- Security:
  - IPSEC – SHA 2
  - AES – 256
  - PSK – Not Clear text
  - HMAC
  - IKE
  - ACL, Source/Destination – Encryption Domain
  - SA – IP authentication

- Default settings:
  - DHCP
  - NAT
  - SNMP

- Authentication:
  - AD, Radius etc.

- SSI Encryption:
  - Preferably tls1.2

8.1.1.4 Testing for LV EG plant

APPENDIX 1 – GRID-TIED SSEG INSTALLATION COMMISSIONING REPORT of the Application for SSEG [Application Form GEN/EMB] specifies the testing requirements of the EG power plant.

8.1.1.4.1 Pre-commissioning and Commissioning Tests

GEN/EMB APPENDIX 1, Declaration by the ECSA professional and the EIR CoC issued by the Registered Person are considered as meeting the due diligence requirements of self-certification by the applicant in terms of safety and quality of supply requirements.

If required by the City, City officials shall perform a simple test by islanding the grid supply and verifying that the EG power plant effectively disconnected from the grid by means of the DGSL, CDD or the integrated inverter disconnect switch. The operation of the reverse power flow blocking protection could also be tested.

GCRPP SCADA signals and controls tests shall be performed by the City's Protection and SCADA branches with the EG.

8.1.1.4.2 Maintenance Tests

The customer is responsible for maintenance of the EG power plant facility in accordance to NRS 097-2 and the manufacturer's recommendations.

8.1.1.5 Supplementary information to NRS 097-2-1

All inverters shall be type tested by an Accredited Body in accordance with NRS 097-2-1 that must be provided for approval by the City. All approved inverters shall be listed on the City's list of approved inverters.

8.2 Medium and High Voltage Embedded Generation

Once published, NRS 097-1 will be adopted by the City of Cape Town as the normative standard for Medium and High Voltage Embedded Generation. RPP, BESF and Network Grid Codes requirements are applicable.

For MV POC, SANS 10142-2 is applicable and the LV requirements of NRS 097-2-1 and SANS 10142-1 are applicable as specified below.

MV customers without a Point of Control protected substation and installing EG greater than 1 MVA must provide a protected substation with indoor switchgear and control gear which will allow for optimal signal, controls and communication via a RTU. RMUs will not be accepted for these type of installations.

8.2.1 Embedded Generation for category A3, B and C with MV or HV POC and PGC connected at MV or HV

8.2.1.1 Requirements

Eskom 240-61268576 standard, subject to MFMA and the City of Cape Town procedures, is adopted until NRS 097-1 is published and is used for MV/HV EG at the point of utility connection (PUC) and point of connection (POC).

Refer to the separate sections related to open access to networks for safe operation, Redundancy, Ownership, Autonomy, Interfaces and Audits.
City of Cape Town Electricity Supply By-law must be adhered to.

Refer to drawing SK5276 Sheet 8. (Note that the drawing is shown for RPP PV technology that can be other RPP technology such as concentrated solar power and rotating generating units, e.g. synchronous or asynchronous generating units used for small hydro, landfill gas, biomass, biogas or wind.)

Eskom 240-61268576 shall apply inter alia for the following areas:

- Means of isolation
- Generator capabilities and operation
- Excitation control and governor requirements
- Synchronization
- Islanded operation
- Fault ride through capabilities
- Requirements for the Utility Network interface
- Fault infeed
- Quality of Supply
- Neutral Earthing
- Prevention of out of synchronism closure
- Requirements for directional protection
- Auto-reclose dead-time settings on networks with Embedded Generation
- Requirements at the PUC and PGC
- Primary equipment
- Protection
- DC systems

There may be certain exceptions and each project must be evaluated on a case-by-case basis.

8.2.1.1.1 Metering

Metering will comply with SANS 474/NRS 057 and SANS 473/NRS 071. The City's procedure for the commissioning of electricity meter installations designed for transformer connected metering systems (EEB 173) will also apply. SADCNC section 8.2 (3), requires the installation of the bidirectional metering equipment between the distributor and the EG's generation facility.

8.2.1.1.2 Supervisory control and data acquisition (for the CCT's/System Operator's Control Centre/s)

Eskom 240-61268576 and South African Grid code shall apply, with exception on a case-by-case basis.

8.2.2 Embedded Generation for category A3 and B with MV or HV POC and PGC connected at LV for EG less than 5MVA

8.2.2.1 General Requirements

POC is either at MV or HV and the decentralised low voltage EG power plant is deep into the customer LV network.

EG of this nature will be limited to < 5 MVA and is considered a deviation from the requirements of 8.2.1. Approval must be obtained from the City if this scheme will be considered and application will be subject to grid and generation engineering studies.

MV customers with EG plant greater than 1MVA shall provide a protected substation with indoor switchgear and control gear which will allow for optimal signal, controls and communication via a RTU. RMUs will not be accepted for these type of installations.

Engineering studies will determine maximum allowable EG plant capacity that cannot exceed the customer NMD.

Out of bounds conditions shall be sensed at the PGC and will operate the disconnecting/isolation devices in compliance with SADCNC, Section 8.4(4) that requires 'A circuit breaker and visible isolation shall be installed at the connection point to provide the means of electrically isolating the Distribution System from the generating facility'.

Refer to drawing SK5276 Sheet 9.

Where a decentralised EG plant combined with customer loads are connected to a common busbar, the generating capacity may not exceed 1 MVA at any decentralised generation point for a PGC at LV in accordance with NRS 097-2-1. Whenever the EG capacity at any point exceeds 1MVA, the requirements of section 8.2.1 shall apply and the PGC for the entire EG installation shall be at MV level (Refer to drawing SK5276 Sheet 8).

8.2.2.2 Open access to networks for safe operation

GCRPP control and signal for Category A3 and above using IEC 60870-5-101 protocol. MODBUS conversion must be robust to ensure the inverters of the EG plant operate as per the GCRPP signals and controls. Refer to Appendix B for the SCADA interface detail in SSEG Cat A3 PLANT IEC*-104 / 101 SCADA_INTERFACE.

8.2.2.3 Redundancy

The failure of any single component or system will not result in unsafe operation.

Refer to NRS 097-2-1, Eskom 240-61268576, attached drawings, and sections below for circuit breaker requirements at the PUC and PGC, protection requirements, loss of grid and DC supplies.

a) No MV or HV generator shall be connected to the City's network via a single circuit breaker. LV EG with capacity above 30 kVA and more than one inverter shall have two in series disconnection devices.
b) Primary system protection provided at the PUC shall be duplicated elsewhere within the EG's facility. The protection requirements are dealt with in Section 8.2.2.11.
c) Loss-of-grid protection as detailed in Section 8.2.2.11.7 shall be provided at the PUC by the EG or if the City owns the PUC circuit breaker(s), then loss-of-grid protection must be applied on the first circuit breaker(s) owned by the EG that can become an islanding point. Note that this protection shall be either the main or back-up loss-of-grid protection dependant on the governing criteria (refer to section above for detailed requirements). Loss-of-grid protection and system integrity checks shall be provided elsewhere in the City's network (e.g. unit, blocking etc.).

d) The DC supplies at the Point of Utility Connection (PUC) and Point of Generator Connection (PGC) shall be independent of one another and shall be subject to continual monitoring (see Section 8.2.2.11.6), both locally and remotely by the owner of the equipment (see Section 8.2.2.11.10).
e) HV connected RPP's shall include dual redundancy on protection, control, D.C. supplies (double banks) and teleprotection circuits.

8.2.2.4 Ownership

Refer to Eskom 240-61268576, attached drawings and sections below.

Three stages of tripping are required:
a) Stage 1: PGC by the EG
b) Stage 2: PUC by the EG
c) Stage 3: Supply circuit breaker by the CCT

Shared responsibility shall exist between CCT and the EG for DC supply, SCADA, and protection integration and the source of the specific service shall be responsible for ensuring the continued supply of the shared service.

8.2.2.5 Autonomy

The EG and CCT shall design, protect, commission and maintain own assets to national and international standards, all parts of the SAGC, NERSA requirements, NRS 097-2-1, City of Cape Town Electricity Supply By-law and this technical standard.

The definitions of PCC, POS, POC, PUC and PGC applies. The PGC closest to the generator, provides back-up to the protection functions of the PUC, and is also subject to minimum technical requirements imposed by the utility and SAGC's.

8.2.2.6 Audits

The City may at any time audit an EG in terms of the agreement and the Electricity Supply By-law.

8.2.2.7 Means of isolation

Every installation or network which includes an embedded generating plant must include a means of isolation, suitably labelled, capable of disconnecting the whole of the embedded generating plant infeed from the distributor's network.

Where the means of visible-break isolation is provided, it must be lockable, in the open position only, by a padlock. Rackable indoor metal clad switchgear is deemed acceptable for this function, provided that it is lockable.

The EG must grant the CCT rights of access to the means of isolation without undue delay. The CCT shall have the right to reasonably isolate the EG's network connection at any time as network conditions dictate. The means of isolation will normally be installed at the PUC, but may be positioned elsewhere with the CCT's agreement.

8.2.2.8 Generator capabilities and operation

8.2.2.8.1 Excitation control and governor requirements

Synchronous generators shall be equipped with excitation controllers capable of connecting and operating on a network of the nominal voltage as per the SAGC requirements.

Induction or asynchronous generators, which are not capable of voltage or reactive power control, are consumers of reactive power. The EG must thus supply reactive power compensation to correct the power factor to within SAGC requirements at the PGC, unless otherwise negotiated with the CCT.

Inverter-type generating equipment can control its power factor over a wide operating range. Thus an EG connecting to the CCT's network via an inverter shall be capable of adjusting the power factor to within a range of SAGC requirements.

The EG shall consult the CCT's standards and shall familiarise themselves with the local operating conditions. The EG's normal operation shall not cause conditions on the network which are outside the accepted power quality standard limits. The generator's excitation control mode must best suit the local environmental conditions.

The South African Grid Codes specifies the continuous operating ranges for generation units.

8.2.2.8.2 Synchronization

All embedded generating plant other than mains excited asynchronous machines must be synchronized with the CCT's supply prior to making the parallel connection.

The voltage and frequency differences between the unit and the system prior to synchronizing shall not differ by more than the values specified in the GCRPP. Where the mode of operation of generating equipment is such that synchronizing of a machine or machines will occur at intervals of less than two hours, the EG shall ensure compliance with the rapid voltage change requirements stipulated in NRS 048-4.

Automatic synchronizing equipment shall be the preferred method of synchronizing. However, manual synchronization of the EG units is permissible on condition that synchronizing check relays (three phase comparators) are used by the EG in conjunction with the manual synchronizing, and that the EG's responsible person is authorised in writing to do so.

It is the responsibility of the EG to provide synchronizing facilities. Section 5 of the GCRPP apply.

8.2.2.8.3 Islanded operation

Intentional islanding of a generator with part of the CCT's network is not permitted unless specifically agreed to with the CCT.

For unintentional islanding, where a generator is synchronised with the CCT's network at the time that an upstream CCT circuit-breaker opens, severing the connection between the generator supply and the grid supply, the generator shall cease to energise the local CCT's network as stipulated in the GCRPP.

8.2.2.8.4 Fault ride through capabilities

The voltage ride through capabilities that the EG shall comply with are specified in Section 5.2.1 of the GCRPP and in the SADCNC for EG that is not deemed renewable (non-renewable EG).

Maximum disconnection times for various under- and over voltage levels for non-renewable EG are stipulated in abovementioned Grid Codes.

8.2.2.9 Requirements for the Utility Network interface

8.2.2.9.1 Fault infeed

When it is proposed to install embedded generating plant, consideration must be given to the contribution that the plant will make to the fault levels on the CCT's network. The design and safe operation of the EG's and CCT's installations depend upon accurate assessment of the fault contributions made by all plant operating in parallel at the instant of the fault. The EG shall discuss this with the CCT at the earliest possible stage. The EG shall provide all relevant information for the CCT to be able to model the generator and its contribution to fault current over time. The fault current in-feed over time must be confirmed in writing to CCT by the EG as per the SAGC.
The fault current in-feed over time must be confirmed in writing to CCT.

- For renewable power plants, the information shall be provided in accordance to A8.2.4 of GCRPP.
  For non-renewable EG power plants, the information shall be provided in the format presented in the Standard IEEE 1547, Table 6: Generator short-circuit current and reactance versus time.

Should the EG result in the increase of fault levels to such an extent that the CCT's or customer's plant at the PUC is placed at risk, the EG shall apply fault current limiting measures to ensure that the fault levels are maintained at acceptable levels. The fault limiting solution applied shall be presented to the CCT for acceptance prior to implementation.

8.2.2.9.2 Quality of Supply

GCRPP and NRS 048 shall apply for all generators. Power quality instrument (s) shall be installed in the CCT substation supplying the POC for any EG above 1 MVA.

8.2.2.9.3 Neutral Earthing

This specification stipulates the neutral earthing philosophy to be applied on EG networks that are galvanically connected to the CCT's supply network. Adequate earthing of networks at other voltage levels within the EG plant is the responsibility of the EG, and is not stipulated herein.

The CCT's networks may use effective, resistive or reactive earthing methods depending on the voltage level and local requirements. The magnitude of the possible earth fault current will depend on which of these methods is used. The EG's earthing arrangement must therefore be designed as follows:

a) In consultation with the CCT such that the EG's system is compatible with the CCT's system.

b) Such that the EG's plant safety is not compromised due to the above requirement.

The actual earthing arrangements will also be dependent on the number of machines in use and the EG's system configuration and method of operation.

Earthing may be achieved by the use of a busbar earthing transformer (e.g. NEC/R), the use of the star point of the generator, or by earthing the star point of the generator transformer.

Care should be taken with multiple generator installations to avoid excessive circulating third harmonic currents. It may therefore be necessary to restrict the earthing to the star point of a single machine and provide automatic transfer facilities of the generator star point earth to another machine in the event of the selected machine being tripped. The use of suitable generator transformers with delta windings may provide a means of avoiding excessive circulating harmonic currents.

The winding configuration of the EG transformers (e.g. Delta-Star, Star-Delta etc.), closest to the POC shall be such that zero sequence currents on the CCT's network and EG systems are decoupled from one another. Due to this, the use of auto transformers are not permitted to connect to the CCTs network.

Where transportable or mobile generating plant is used, it is essential that all earthing connections to the generator are effectively made prior to making off any phase connections or running the generator.

Under conditions of separation between the CCT's network and the EG system, care must be taken to not run any part of any of the systems unearthed.

HV networks

HV networks are required to be effectively earthed. The HV generator transformer winding shall therefore cater for solid earthing of the neutral using a Star-connected winding at the side of the transformer connecting to the CCT's network.

MV networks

CCT's MV networks are generally resistively earthed at the source substation so as to limit earth fault currents to the typical range between 600A and 3200A

The preferred neutral earthing philosophy for MV-connected generator transformers is such that the MV neutral point directly connecting onto the CCTs network (at the POC) be left un-earthed. This will serve to avoid issues of earth fault relay de-sensitization, as well as avoiding "circulating" zero sequence or triplen harmonic currents between the distant earth connections.

No MV connected generators will be allowed to connect directly to the network. This means that an isolating transformer(s) is required at the POC. An auto-transformer is not acceptable as it does not provide isolation.

With the EG not earthing the MV network, and in the case of the source tripping as a result of a line earth fault, the healthy line voltages will be raised to full phase-to-phase values. In addition, there is a possibility of resonant over-voltages arising from the generator transformer reactance and the line capacitance. Possible damage to surge arresters may be avoided by specifying arrester Maximum Continuous Over Voltage (MCOV) values at the full phase-to-phase voltage and grading the over-voltage protection functions with regard to the surge arrester temporary over-voltage (TOV) curves.

In the absence of a MV neutral earthing point at the point of connection, line earth faults will be detected by phase-to-earth under-voltage and/or residual over-voltage protection (i.e. a neutral to earth VT), and also over-frequency protection as a result of the generator supplying a lightly loaded or unloaded island. Under-voltage protection located on the generator-side of the generator transformer may not be adequate on account of the voltage balancing effect of the transformer (depending on the winding configurations).

8.2.2.9.4 Prevention of out of synchronism closure

The CCT shall provide synchronism check and/or live-line close blocking functionality on all circuit-breakers and/or pole-mounted switchgear between the Embedded Generator's PUC and the SSP. This shall serve as additional security against possible out-of-phase closure onto an islanded EG power plant. Synchronising (auto or manual) shall remain the sole responsibility of the EG and this shall be done at the PUC, PGC, and/or elsewhere within the EG's plant.

8.2.2.9.5 Requirements for directional protection

In many cases, the fault current infeed from the EG plant to network faults will be a small fraction of the grid-supplied fault current. The fault current infeed from the generator may also decay rapidly with time. As a result, it is unlikely that the traditional non-directional overcurrent, earth fault and SEF protection applied to radial MV and HV Distribution networks will be rendered unsuitable by the presence of an EG power plant. This must, however, be confirmed during the design phase of each project.

8.2.2.9.6 Auto-reclose dead-time settings on networks with Embedded Generation

Auto-reclose dead-time settings on all circuit-breakers between the PUC and the SSP shall be increased from the standard 3 seconds to at least 5 seconds so as to provide additional margin for the detection and isolation of possible power islands.

8.2.2.10 Requirements at the PUC and PGC

This section details the requirements for the primary- and control plant equipment to be installed at the PUC and PGC.

8.2.2.10.1 Current Transformers

Current transformers shall be specified in accordance with NRS 029. Protection CTs shall be in compliance with the protection relay manufacturer's requirements with regard to accuracy class. Metering circuits shall use Class 0.2 CTs. Refer to Section 8.2.2.13 for further requirements with respect to metering CT cores for the CCT's use. Measurement circuits shall use Class 0.2 CTs or protection class CTs. Protection class CTs will typically be used for measurements where the measurement data is derived from a protection relay instead of a stand-alone transducer.

8.2.2.10.2 Voltage Transformers

Voltage transformers shall be specified in accordance with NRS 030. Metering and measurement circuits shall use VTs of accuracy Class 0.2. Protection VTs shall be of Class 3P accuracy. The VTs shall be burdened so as to ensure accuracy within class definitions.

8.2.2.10.3 Isolator/Disconnector

The isolator fulfilling the requirements of Section 8.2.2.7 shall be specified in accordance with NRS 031 and the normative references.

The isolator shall include at least one normally-open and one normally-closed auxiliary status contact for use by the CCT for remote indication purposes. The contacts shall operate in the fully-open and fully-closed positions of the primary contacts respectively. These contacts may not be provided by a separate relay or device not forming an integral part of the isolator.

The isolator shall be lockable using a standard utility padlock (where applicable):

a) Case: 35 mm – 38 mm high, 28 mm – 40 mm wide, 18 mm – 20 mm thick; and
b) Shackle: 6 mm diameter, 30 mm-34 mm length (in the locked position), 20 mm width (minimum).

8.2.2.10.4 Circuit-Breakers

The circuit-breakers shall comply with the requirements of SANS 62271 suite (e.g. Part 100) and shall be suitably rated to interrupt the maximum prospective fault current at the PUC or PGC as appropriate.
To allow for network growth the fault interruption capability of circuit-breakers shall be chosen to be at least 30 % higher than the maximum fault levels calculated in the initial integration study for the EG plant.

The maximum circuit-breaker operating times shall be as follows:

a) HV network: < 60 ms
b) MV network: < 100 ms

The circuit-breakers shall have a “maximum over-voltage” factor for switching conditions of SANS 62271-100 of 2.5 pu or higher.

The circuit-breakers shall include at least one normally-open and one normally-closed auxiliary status contact for use by the CCT for remote indication purposes. These contacts may not be provided by a separate relay or device not forming an integral part of the circuit-breaker.

8.2.2.11 Protection

This section details the protection functionality that shall be installed at the PUC or deeper in the EG’s network, irrespective of whether the same functionality is installed in the inverters.

Protection requirements are also stipulated for the PGC, providing back-up to the PUC protection. The protection systems shall provide adequate protection of the parts of the Distributor’s network that could be supplied by the EG, either in parallel operation or under conditions of the EG supplying an intentionally islanded portion of the CCT’s network.

Further, the protection systems shall:

a) Inhibit connection of the generating equipment to the grid supply unless all phases of the CCT’s supply are energized and operating within the agreed limits;
b) Disconnect the generator from the system when a system abnormality occurs that results in an unacceptable deviation of the voltage or frequency at the point of connection; and
c) Prevent un-intentional islanding of the EG plant with a portion of the CCT’s network.

Table 1 includes a summary of specific protection functions that shall be provided at the PUC or deeper in the EG’s network.
Table 2 includes a summary of specific protection functions that shall be provided at the PGC.

1	2	3	4
Protection Type	**Section**	**HV**	**MV**
Overcurrent, Earth Fault	8.2.2.11.2	Yes	Yes
Sensitive Earth Fault (SEF)	8.2.2.11.2	No	Note 1
Phase Under/Over Voltage	8.2.2.11.3	Yes	Yes
Residual over-voltage	8.2.2.11.4	No	Note 1
Under/Over Frequency	8.2.2.11.5	Yes	Yes
Loss-of-Grid	8.2.2.11.7	Yes	Yes
Check Synchronising / interlocking (Block dead line charge)	8.2.2.11.8	Yes	Yes
Reverse Power	8.2.2.11.9	Note 2	Note 2
DC Failure Monitoring	8.2.2.11.6	Yes	Yes
NOTE 1: Depends on neutral earthing philosophy adopted. Neutral voltage displacement protection will be applied on networks where the EG or generator transformer does not provide an earth connection to the CCT's network. Earth Fault and Sensitive Earth Fault protection will be required in the event that an earth connection is provided **NOTE 2:** Reverse power protection shall be applied in the event that the EG does not plan to, or is not permitted to export power to the grid, but which will be synchronised with the grid.			

Table 1 – PUC protection requirements per voltage level

NOTE: The requirements of this section indicate CCT's minimum requirements at the PUC and PGC so as to safeguard the CCT's network in the event of faults within the EG's facility, or faults on the CCT's network with a fault current contribution from the EG plant. In keeping with the requirements of the SADCNC, the EG may require additional protection (e.g. biased differential, Restricted Earth Fault, pole slipping protection, negative phase sequence overcurrent etc.) to safeguard his assets against damage due to abnormal events or faults on the power system.

Notwithstanding the requirements of Table 1 for the PUC, Table 2 lists the minimum protection functionality to be installed at the PGC.

1	2
Protection Type	**Section**
Phase Under/Over Voltage	8.2.2.11.3
Under/Over Frequency	8.2.2.11.5
Auto synchronising (Note 1)	8.2.2.11.8
Reverse Power (Note 2)	8.2.2.11.9
DC Failure Monitoring	8.2.2.11.6
NOTE 1: Where synchronism protection is not an inherent function of the generator (rotating machine, PV etc.), provision must be made for synchronism protection at the PGC. If the EG plant can operate as an island then the EG plant shall perform check synchronising at the PUC and prevent energising CCT network i.e. block dead line charge.	

NOTE 2:
For rotating machine generators, reverse power protection is required at the PGC. Reverse power protection shall be applied at the PUC in the event that the EG does not plan to, or is not permitted to export power to the grid, but which will be synchronised with the grid.

Table 2 – PGC Protection requirements

Section 3.1 of the SADCNC requires generators to be provided with back-up impedance and circuit-breaker fail protection in addition to the requirements of Tables 1 and 2 above.

In the event that the PUC and the PGC are the same point (e.g. for MV directly-connected generators) the protection system at the combined PUC/PGC shall comply with the requirements of both Tables 1 and 2. In addition, the CCT shall install a back-up circuit-breaker on the CCT-side of the PUC. The back-up circuit-breaker (typically an auto-recloser) shall include protection functionality as indicated in Table 3.

1	2
Protection Type	**Section**
Overcurrent, Earth Fault	8.2.2.11.2
Sensitive Earth Fault (SEF)*	8.2.2.11.2
Phase Under/Over Voltage	8.2.2.11.3
Under/Over Frequency	8.2.2.11.5
Check Synchronising / interlocking (Block dead line charge)	8.2.2.11.8
DC Failure Monitoring	8.2.2.11.6
* where applied at the PUC/PGC	

Table 3 – Back-up circuit-breaker protection requirements (combined PUC/PGC)

8.2.2.11.1 General protection requirements

a) All protection relays used at the PUC and PGC shall comply with the type test requirements of Appendix C.

b) Protection relay accuracy requirements of the following sections shall be defined as per IEC 60255-3 and -6.

c) Except where the PUC and PGC are the same point, the PUC and PGC protection shall be totally independent of each other.

d) Protection clearance times and coordination shall comply with the requirements specified as a result of the EG integration fault studies.

e) If automatic resetting of the protective equipment is used (e.g. for an unmanned EG facility), the time delays must be applied in consultation with the regional auto-reclose philosophy. The automatic reset must be inhibited for faults within the EG installation.

f) Each protection relay system shall include a sequence of event recording function that logs any settings change; settings group change, protection pick-up or trip operation, or change in circuit-breaker and/or input and output status.

g) The relay system installed at the PUC shall incorporate an oscillographic waveform recording function capable of storing at least five 15-cycle recordings at a sampling rate of 16 samples per cycle or higher. The waveform recording shall contain the three phase voltage, three phase current and neutral current signals from the PUC as well as all significant digital signals (i.e. protection tripping elements, circuit-breaker status, input and output contact status etc.). A recording shall be triggered upon any protection operation.

h) The event and waveform recordings shall be stored in non-volatile memory and shall be time stamped with a resolution of 1 millisecond real time. It shall be possible for the recordings to be made available in COMTRADE format.

i) Protection settings for all functions identified in tables 1, 2, and 3 to be applied at the PUC and PGC will be to the CCT's written approval. No changes to the settings shall be made without written consent from the CCT. The EG shall keep written record of all protection settings, and provide a signed electronic copy of the same to the CCT.

8.2.2.11.2 Overcurrent, earth fault and sensitive earth fault protection

Overcurrent and earth fault protection shall provide Inverse Definite Minimum Time (IDMT) time-current characteristics. IDMT curves shall be in accordance with the requirements of

IEC-60255-3: Type A, B and C curves (i.e. IEC Normal Inverse, Very Inverse and Extremely Inverse).

Overcurrent protection will be provided in all cases. Voltage-controlled overcurrent protection shall be considered in applications where the fault current contribution of EG power plant decays with time.
Appropriate Earth Fault protection will be applied in all cases. Current-based detection is not appropriate in MV networks where the generator or generator transformer does not include a point of neutral earthing.

Sensitive Earth Fault protection will be applied on MV networks where the generator or generator transformer provides a point of neutral earthing to the CCT's network. SEF protection will be set in compliance with Eskom Distribution Standard 240-76628317(DST 34-540): Protection Settings Philosophy for Medium Voltage Distribution Networks. Standard for the application of Sensitive Earth Fault protection will use a definite time characteristic.

The overcurrent, earth fault and SEF protection shall be set to coordinate with the CCT's network protection as dictated by the integration fault studies.

8.2.2.11.3 Under and over voltage protection

Under- and over-voltage protection shall be provided. The voltage protection functions shall detect the effective (i.e. root mean square) or the fundamental component of each phase-to-phase voltage. GCRPP Section 5 shall apply. In cases where the EG facility may import or export power from the CCT's network, the voltage protection may be supervised so as only to operate in the event of real and/or reactive power being exported by the facility to the network.

8.2.2.11.4 Residual over-voltage / neutral voltage displacement protection

Residual over-voltage (also known as neutral voltage displacement) protection shall be applied on MV networks where the generator or generator transformer MV neutral is unearthed. The voltage signal must be derived from a VT configuration that is capable of transforming zero-sequence voltage: three single phase VTs or three phase 5-limb VTs, with primary neutral earth connection.

The residual voltage may be derived from a broken-delta configuration of the VTs, or may be calculated by the relay based on the measured phase-to-neutral voltages.

The pick-up and time delay of the residual over-voltage protection shall be chosen so as to grade with the current-based earth fault protection that is applied to the CCT's network. It is preferred that the residual over-voltage protection uses an inverse voltage-time characteristic rather than a definite time characteristic. The residual over-voltage protection will be less sensitive and slower than the Distribution network protection. Refer to annex D for a worked grading example.

8.2.2.11.5 Under and Over Frequency protection

Under- and over frequency protection shall be provided. The under- and over frequency protection relay shall be accurate to within 10 millihertz of setting. Where an averaging "window" is used for the frequency measurement, this shall be limited to a maximum length of 6 cycles.

The frequency protection shall be set so as to allow generator operation within the frequency ranges stipulated in GCRPP. Operation outside these ranges shall cause the EG power plant to sever the connection with the CCT's network within 300 ms.

In cases where the EG facility may import or export power from the CCT's network, the frequency protection may be supervised so as only to operate in the event of real power export by the facility to the grid.

GCRPP Section 5 applies.

8.2.2.11.6 DC Failure Monitoring

DC failure within the EG facility is deemed a serious safety risk. The DC supplies provided for the Protection relay and associated protection systems shall be subject to continual monitoring for precise operation of the relays. Two separate DC alarms shall be provided per DC system:

a) Non-urgent DC alarm: an alarm activated when the battery voltage is lower than normal, or for any fault appearing on the AC supply to the battery charger.
b) Urgent low DC voltage alarm: an alarm activated when the battery voltage is such that the available capacity is less than 20 % of the rated Ampere-hour capacity.

The EG shall initiate disconnection from the Distribution network immediately upon receipt of an urgent low DC voltage alarm.

8.2.2.11.7 Loss-of-Grid protection

Operation of an EG plant in an unintentional islanded mode with part of the distribution network constitutes a serious safety hazard to both equipment and personnel, and is to be avoided as far as is practicable.
The philosophy to be applied is that the detection of an islanding condition shall take precedence over the continuity of the generator's grid connection.
Dedicated loss-of-grid protection will be applied at the PUC in all applications. An EG may be exempted from this requirement in the event that it is prohibited from exporting real power to the Distribution network by a suitable reverse power relay.
Loss-of-grid protection may take the form of Rate-of-Change of Frequency (ROCOF) as shown in Table 4.

1	2	3
ROCOF	Δf	0,2 – 1,0 Hz/s (0,4 Hz/s typical)
	Δt	40 ms – 2 s
	Time delay	200 ms – 500 ms

Table 4 – Typical settings for loss-of-grid protection

8.2.2.11.8 Check synchronising / block dead line charge

The circuit-breaker at the PUC shall be blocked from closing onto a de-energised Distribution network (block dead line charge). Charging of the EG network shall be permitted subject to synchronism check having been performed.

Synchronising shall be done at the PGC, in accordance with the requirements of Section 8.2.2.8. Where synchronising occurs at the PUC, for situations where the EG plant would island onto his own internal network, the PUC shall also adhere to the requirements 8.2.2.8.

8.2.2.11.9 Reverse power protection

There are two principal applications of reverse power protection, namely:

1) Prevention of generator motoring.

This shall be applied as standard at the PGC on all rotating generators.
The recommended setting for a reverse power relay is 10 % – 20 % of the maximum allowable motoring power. The operating time is typically 10 s – 30 s. The time delay is required to prevent maloperation during power swings or when synchronising the generator to the network

2) Prevention of power export to the grid

A reverse power protection relay may be installed at the PUC of an EG whose entire output will be consumed by the plant in which it is embedded. The reverse power protection relay will prevent unintended export of power to the CCT's network, and may obviate the need for dedicated loss-of-grid protection (see Section 8.2.2.11.7). When serving as loss-of-grid protection, the reverse power protection relay shall be graded with time overcurrent protection in order to ensure ride-through during fault conditions. The clearance times shall comply with the requirements determined by the EG integration fault studies.

8.2.2.11.10 DC systems

The circuit-breakers and associated protection systems at the PUC and PGC shall operate from independent DC supplies.

The DC supplies to the PUC and PGC shall be subject to continual monitoring as per Section 8.2.2.11.6. The EG shall cease to energise the CCT's network upon critical failure of either the DC system at the PUC or that at the PGC or both.

The DC systems at the PUC and PGC shall be maintained in accordance with the applicable CCT's standard or an alternative written policy acceptable to the CCT The CCT reserves the right to perform audits on the DC systems.

8.2.2.12 Metering

Metering will comply with SANS 474/NRS 057 and SANS 473/NRS 071. The City's procedure for the commissioning of electricity meter installations designed for transformer connected metering systems (EEB 173) will also apply. SADCNC section 8.2 (3), requires the installation of the bidirectional metering equipment between the distributor and the EG's generation facility.

8.2.2.13 Supervisory control and data acquisition (for the CCT's/System Operator's Control Centre/s)

8.2.2.13.1 General requirements

There shall be an RTU at the PUC and at the PGC. Where these are the same location, a single RTU may be provided.

The RTU(s) shall be in accordance with the CCT's standard and shall be supplied, installed, commissioned and maintained by the EG. The EG must provide the civil works in which the equipment will be installed. RTUs at the EG facilities shall interface with the CCT's RTU which intern will interface with CCT's control centre.

8.2.2.13.2 Indications and alarms

The method of communication from the EG's RTU to the CCT's RTU is with a Multi-Mode fibre connection via IEC 60850-5-101 protocol.

In addition to the GCRPP requirements for indications and alarms the following shall be provided to the RTUs by the EG:

1) PUC and PGC circuit-breaker open and closed indications (Double Bit);
2) Isolator open and closed indications (Double Bit) – only required from the PUC;
3) Non-urgent DC alarm
4) Urgent low DC voltage alarm
5) Protection trip indication
6) Manual trip indication

8.2.2.13.3 Controls

In addition to the GCRPP requirements for control, the control of the PUC breaker will be required. Switching of the EG's equipment by the CCT shall only be conducted under emergency conditions, or as arranged between the parties.

8.2.2.13.4 Measurements

In addition to the GCRPP requirements the following power system measurements shall be provided to the RTU either via the DNP3.0 Ethernet or IEC 60850-5-104 / 101 protocols.

1) The true RMS red-to-white phase voltage (kV): ± 0.5 %;
2) The true RMS white phase current (A), range 0 to 1.1 x ∆full load: ± 0.5 %;
3) The three-phase active power in kW/MW: ± 0.5 % (Import and Export);
4) The three-phase reactive power in kVar/MVar: ±∆0.5 % (Import and Export); and
5) The frequency (Hz): ±∆ 0.1 %

8.2.2.14 Testing for MV and HV EG plant

NRS 097-2-1: 2017 inverter type testing is required by an Accredited Body.

APPENDIX 1 – GRID-TIED SSEG INSTALLATION COMMISSIONING REPORT of the Application for SSEG [Form GEN/EMB] specifies the testing requirements of the EG.

All the applicable requirements of the Eskom 240-61268576 and Grid Codes apply.

8.2.2.15 Pre-commissioning and Commissioning Tests

All RPP and BESF Grid Codes Signals and Controls shall be tested and confirmed.

GCRPP SCADA signals and controls tests shall be performed by the City's Protection and SCADA branches with the EG.

8.2.2.16 Maintenance Tests

The customer is responsible for maintenance of the EG facility. This includes maintenance tests that will provide assurance that the EG facility performs to design and safety specifications.

8.2.3 Non-renewable embedded generator

8.2.3.1 General Requirements

This section sets out the minimum technical and statutory requirements for the interconnection of non-renewable embedded generator operated in parallel with the City of Cape Town's electrical networks, typically thermal synchronous and/or asynchronous generator units

Requirements applies to all non-renewable embedded generators where the generating plant may be paralleled with the CCT's network permanently, periodically or temporarily and sets out the specific requirements for grid tied non-renewable embedded generators, in accordance with the RSA Distribution Codes and SAGC Transmission grid codes that are applicable. Compliance is required with this section when EEB317: Standby Supply Soft Load Transfer Scheme is not applicable.

8.2.3.2 Embedded Generator Connection Conditions

As defined in the SADCNC, Section 8, 8.1, 8.2, 8.3 and 8.4 shall be applicable to EGs below 10MVA. The SATGCNC shall apply for EGs above 10 MVA.

8.2.3.3 Protection Requirement for Embedded Generators: General Protection Requirements

As defined in the SADCNC, Section 8.4.1.1.

8.2.3.4 Specific minimum Protection Requirements

a) As defined in the SADCNC, Section 8.4.1.2.
b) Appropriate requirements of EEB 705, Section 8.2.2.11 and SADCNC applies for EG less than 5 MVA. SADCNC and Eskom 240-61268576 applies to 5 MVA and above. The SATGCNC, Section 3.1 applies specifically for EG above 10 MVA.
c) Synchronism check required before the circuit breaker is closed and the EG is connected to power system. For EGs less than 10 MVA with rotating synchronous generators, IEEE Standard 1547.2 -2008 Table 3 shall apply.

Aggregate rating of distributed resources (DR) units (kVA)	Maximum Frequency difference (∆ f, Hz)	Maximum Voltage difference (∆ V, %)	Maximum Phase angle difference (∆ φ, °)
0 - 500	0.3	10	20
>500 - 1500	0.2	5	15
>1500 - 10 000	0.1	3	10

Table 5 – Typical synchronising parameter limits (Derivative from IEEE Standard 1547.2 - 2008 Table 3)

For EGs above 10 MVA with rotating generators: SADCNC for power stations (Section 9), SATGCNC, NTC/SO requirements and Eskom 240 – 612685576 shall apply.

d) General: In terms of specific requirements for grid tied non-renewable embedded generators, the appropriate sections of 8.2.2 of EEB 705 are applicable.

8.2.3.5 Quality of Supply (QoS) Requirements

a) Power quality instrument(s) shall be installed in the CCT substation supplying the POC for any EG above 1 MVA and any non-renewable rotating plant. The associated cost will be quoted by CCT.

b) As defined in the SADCNC, Section 8.4.1.3 and NRS 048.

c) Fault level studies shall be carried by both the EG and NSP. NSP will complete the studies after an application is received from the EG including all their network and generator information and payment of grid studies. The information shall be provided in the format presented in the Standard IEEE 1547.2 - 2008, Table 6: Generator short-circuit current and reactance versus time.

Generator kV Base:	
Generator kVA Base:	
Generator I base:	

Constants:

Subtransient Time Constant (sec)	T"	
Transient Time Constant (sec)	T'	

Subtransient Reactance (pu)	X"	
Transient Reactance (pu)	X'	
Synchronous reactance (pu)	X	

For a three phase fault at generator terminals, provide the following currents (generator operating independently in island mode):

Generator terminal Voltage		1 pu
Subtransient Current (pu)	I"	
Transient Current (pu)	I'	
Steady State Current (pu)	I	

Equations:

I (t)	I(t) = (I" – I')e^(–t/T") + (I' – I)e^(–t/T') + I
Equivalent X (pu)	X(t) = Vpu/I(t)

For a three phase fault at generator terminals, provide I(t) and X(pu) in the table below:

Time	cycles	1	2	3	5	7	10	20	30	50	70	100	200	300	500	700	1000
	(t) seconds	0.02	0.04	0.06	0.1	0.14	0.2	0.4	0.6	1	1.4	2	4	6	10	14	20
I (t)																	
X(t)																	

Table 6 – Typical generator short-circuit current and reactance versus time (Derivative from IEEE Standard 1547.2 -2008 Table 6)

8.2.3.6 Telemetry Requirements

a) As per SADCNC, Section 8.5 the following signals/analogues are required by the CCT

b) Non-renewable EGs less than 10 MVA as follows:

i. Breaker status at the POC (Open/Close) and at PGC when generator is embedded within customer network.

ii. Isolator status (Open/Close) if installed at the POC and at PGC. Withdrawable circuit breaker in the racked out/in state can be used an alternative. Generation State (Generating/Shutdown)

iii. Earth switch (Open/Close) if installed, separate indication at POC and PGC.
iv. Active Power Imported/Exported (-/+MW) at the POC
v. Ramp rates set-point feedback (Up Ramp/ Down Ramp)

c) Non-renewable EGs above 10 MVA as per SADCNC for power stations (Section 9), SATGCNC, NTC/SO requirements shall apply. The minimum requirements shall be 8.2.3.6.b. above with the addition of frequency (Hz) and reactive power (-/+ MVAr).

Refer to Appendix B for the SCADA interface detail in NON RENEWABLE GENERATOR IEC*-101 SCADA INTERFACE.

8.2.3.7 Point of connection (POC) technical requirements.

The customer will be cost responsible for any changes required to the distribution network upstream and downstream of the POC.

8.2.3.8 Drawings

a) SK5276 Sheet 10: Non-renewable embedded generator with gen transformer
b) SK5276 Sheet 11: Non-renewable embedded generator – LV embedded

8.2.3.9 Operational and safety aspects

EEB 705, Section 7 appropriate detail shall apply inclusive of an annexure for Embedded Generator Technical Details.

9 RESPONSIBILITIES

Define the various responsibilities associated with the implementation of the standard.

CCT Tasks	**Customer**	**Contractor**	**CCT Engineering SCP**	**CCT Protection**	**CCT Sustainable Energy Markets**	**CCT Metering**	**CCT Network Control**
Define service connection standards for embedded generation and address queries			A,R	C	I	C	I
Define public awareness and communication standards for embedded generation	C,I	C I	C,I	C, I	A,R	C,I	
Define protection and Scada standards for embedded generation and address queries.	I	I	C	A, R	I	C	C
Define metering requirements for embedded generation and address queries	I	I	C,I	C,I	I	A	I

Customer and Contractor Tasks	**Customer**	**Contractor**	**CCT Engineering SCP**	**CCT Protection**	**CCT Sustainable Energy Markets**	**CCT Metering**	**CCT Network Control**
Measure compliance with CCT standards for embedded generation in new installations	A,R	A,R	C	C	C	C	
Measure compliance with CCT standards for embedded generation in existing installations	A,R	A,R	C	C	C	C	C
Measure Grid Code compliance – technical requirements of this standard only	A,R	A,R	C	C		C	C
Acceptance testing of signals between EG and City networks	A/C	C		R			R

Table 7: Accountable (A), Responsible(R), Consulted (C) and Informed (I) roles table for implementation of this technical standard

10 ACKNOWLEDGEMENTS

This document draws heavily from the norms and standards described in the Eskom 240-61268576: Standard for the interconnection of embedded generation, related material and the Eskom 240-126260252: The dead-grid safety lock specification and minimum requirements for LV connected photovoltaic embedded generators.

City of Cape Town would like to acknowledge Eskom for the material used by the City through the valid Eskom Power Delivery Engineering (PDE) web annual subscription.

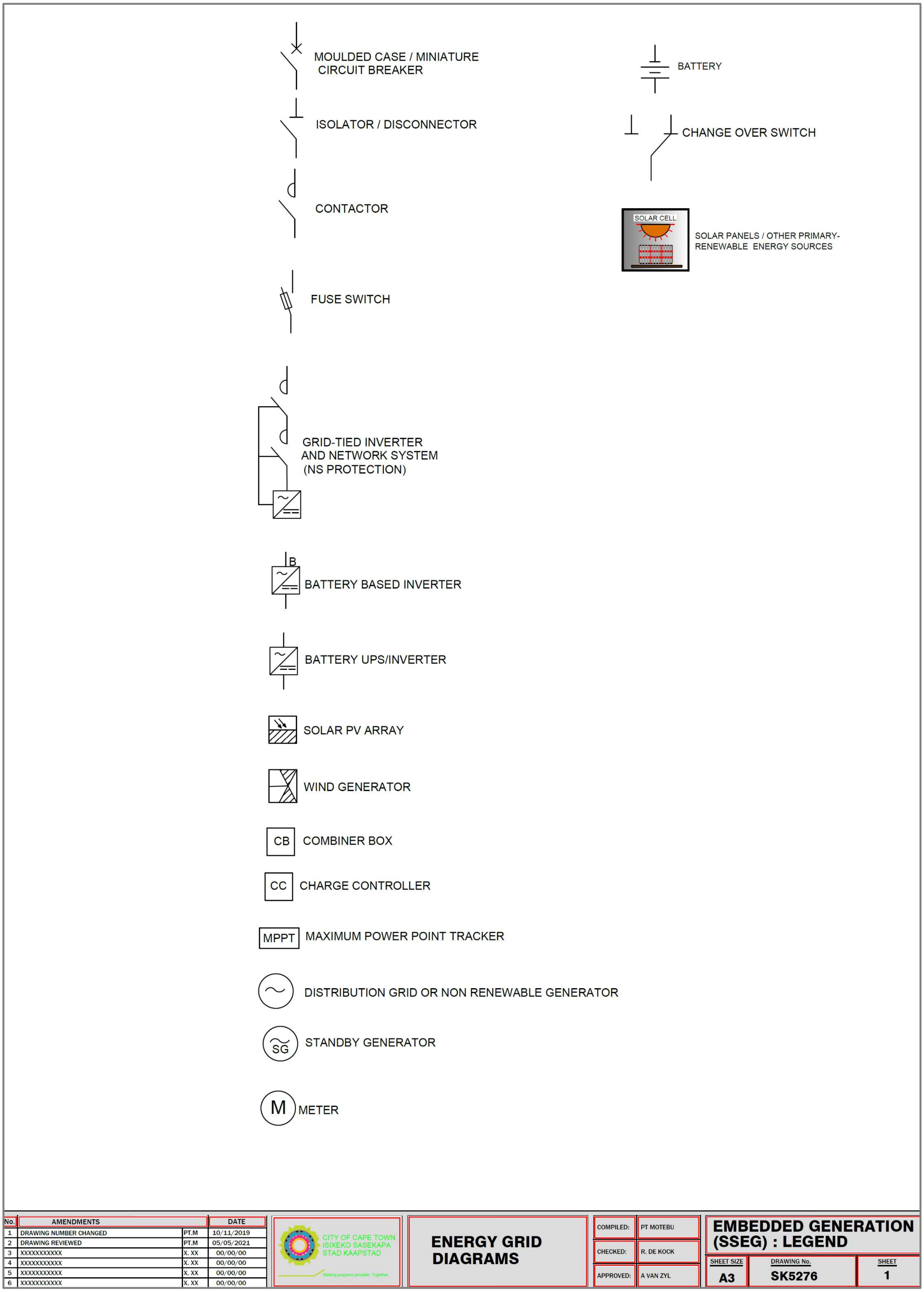
11 REVISIONS

This revision replaces Revision 0.

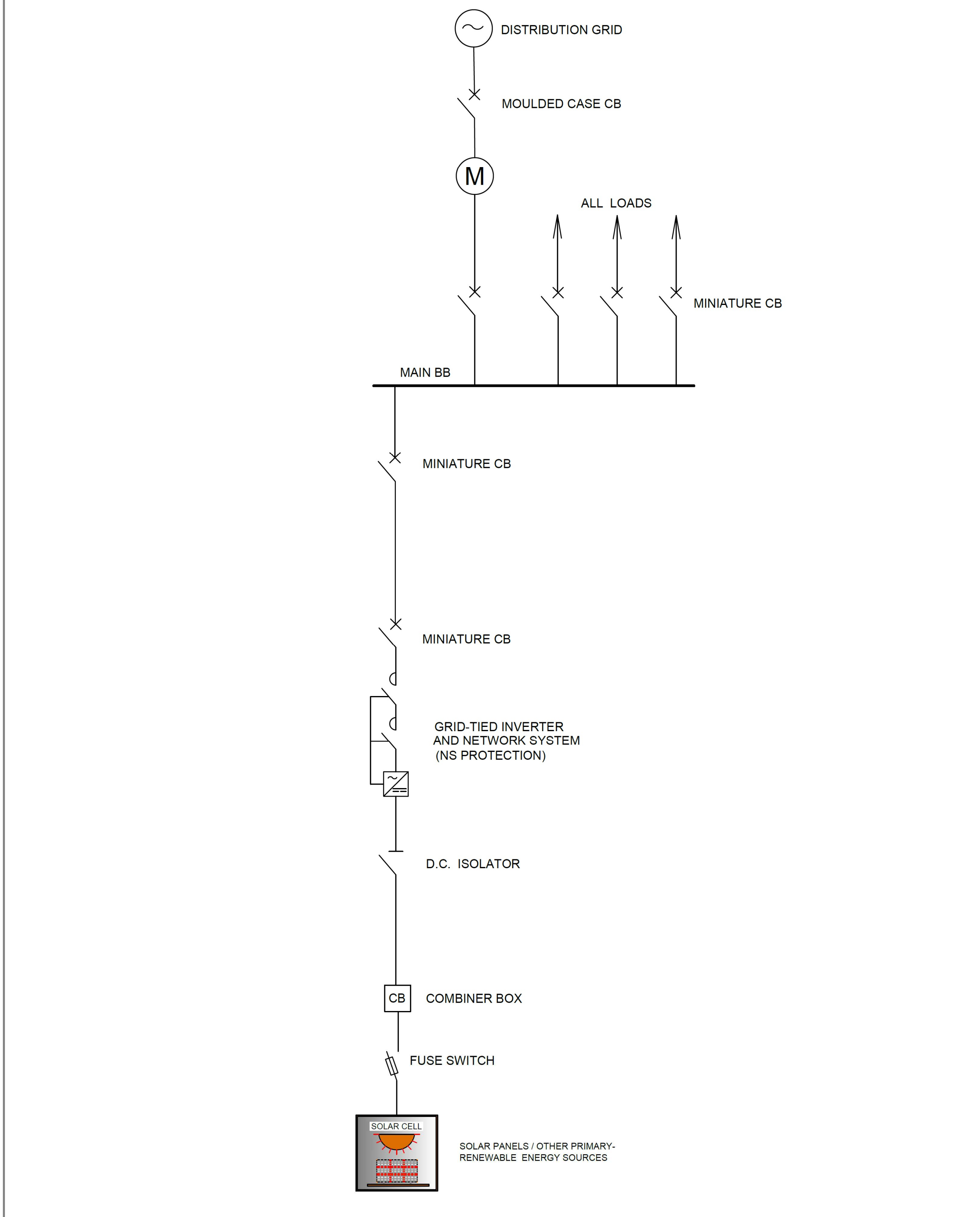
Date	Revision	Compiled by	Clause	Remarks
February 2022	1	R van der Riet	4 8.2.1 & 8.2.2 8.2.2.9.2 8.2.3	Added definitions, abbreviations Added HV and updated drawings QoS instrument added Non-renewable EG added

Appendix A: Drawings

SK5276 Sheet 1: Embedded Generation (SSEG): Legend



SK5276 Sheet 2: Grid-tied EG plant with no storage



No.	AMENDMENTS		DATE
1	DRAWING NUMBER CHANGED	PT.M	10/11/2019
2	DRAWING REVIEWED	PT.M	05/05/2021
3	XXXXXXXXXXX	X. XX	00/00/00
4	XXXXXXXXXXX	X. XX	00/00/00
5	XXXXXXXXXXX	X. XX	00/00/00
6	XXXXXXXXXXX	X. XX	00/00/00

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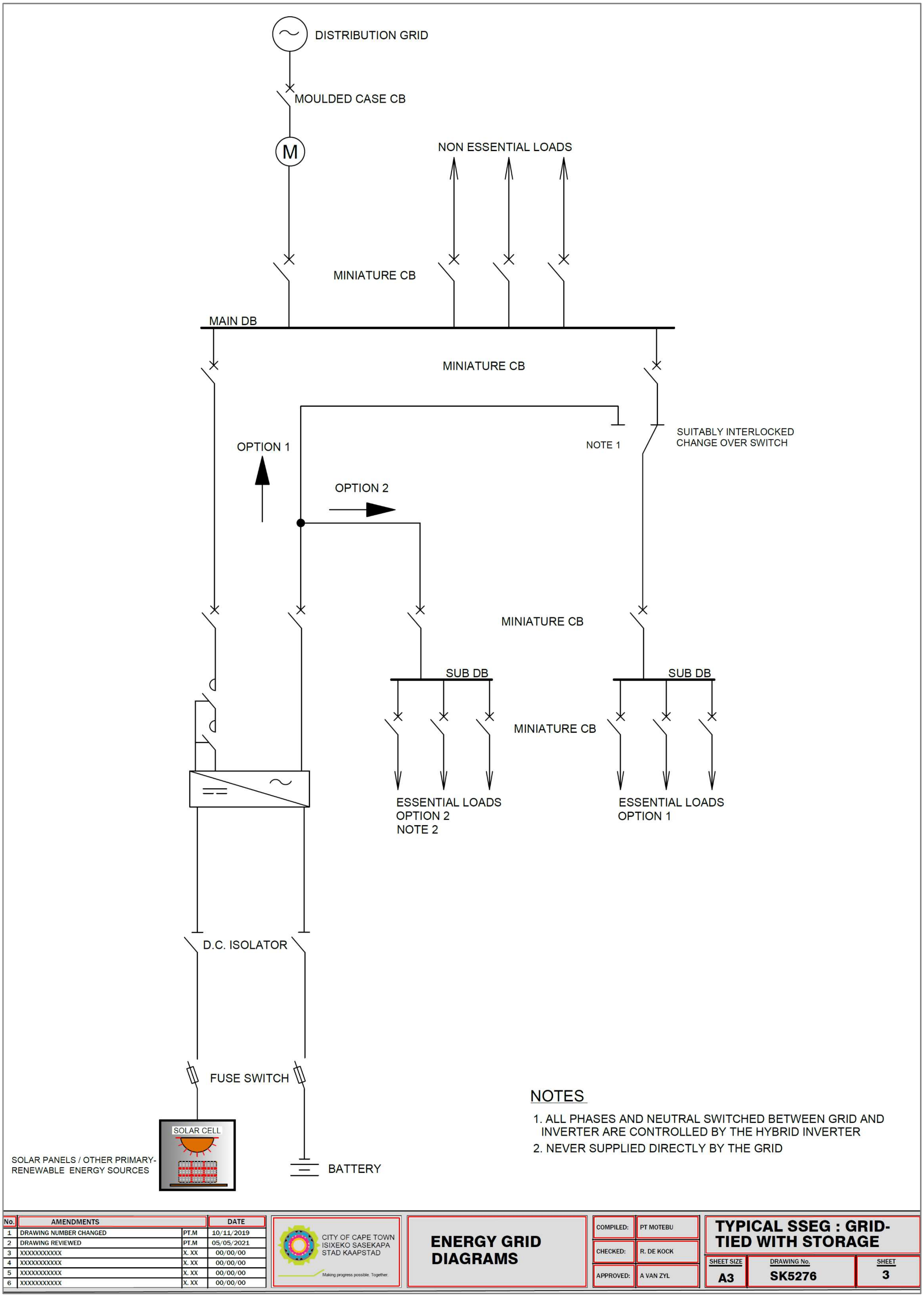
ENERGY GRID DIAGRAMS

COMPILED:	PT MOTEBU
CHECKED:	R. DE KOCK
APPROVED:	A VAN ZYL

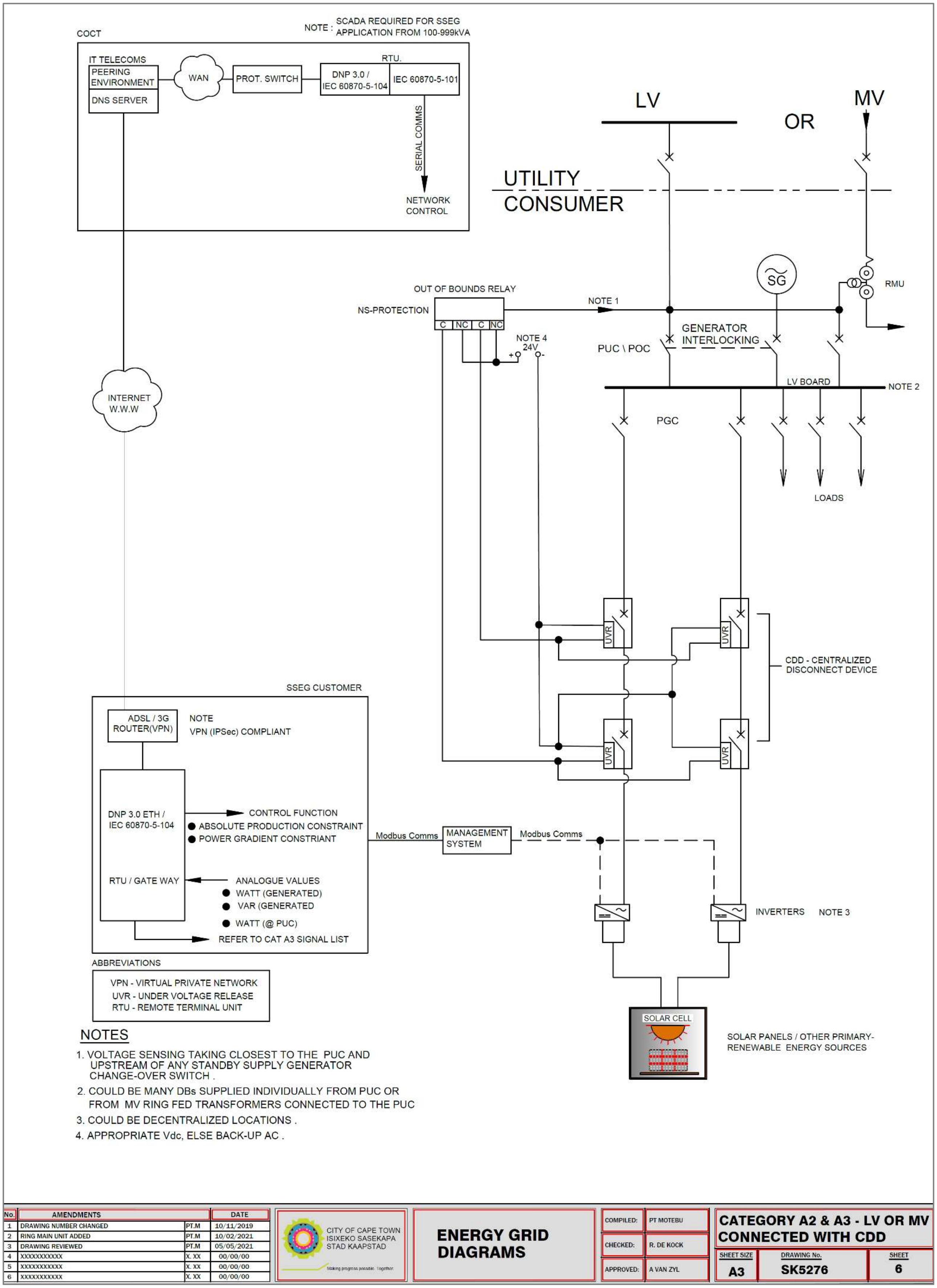
TYPICAL SSEG : GRID-TIED WITH NO STORAGE

SHEET SIZE	DRAWING No.	SHEET
A3	SK5276	2

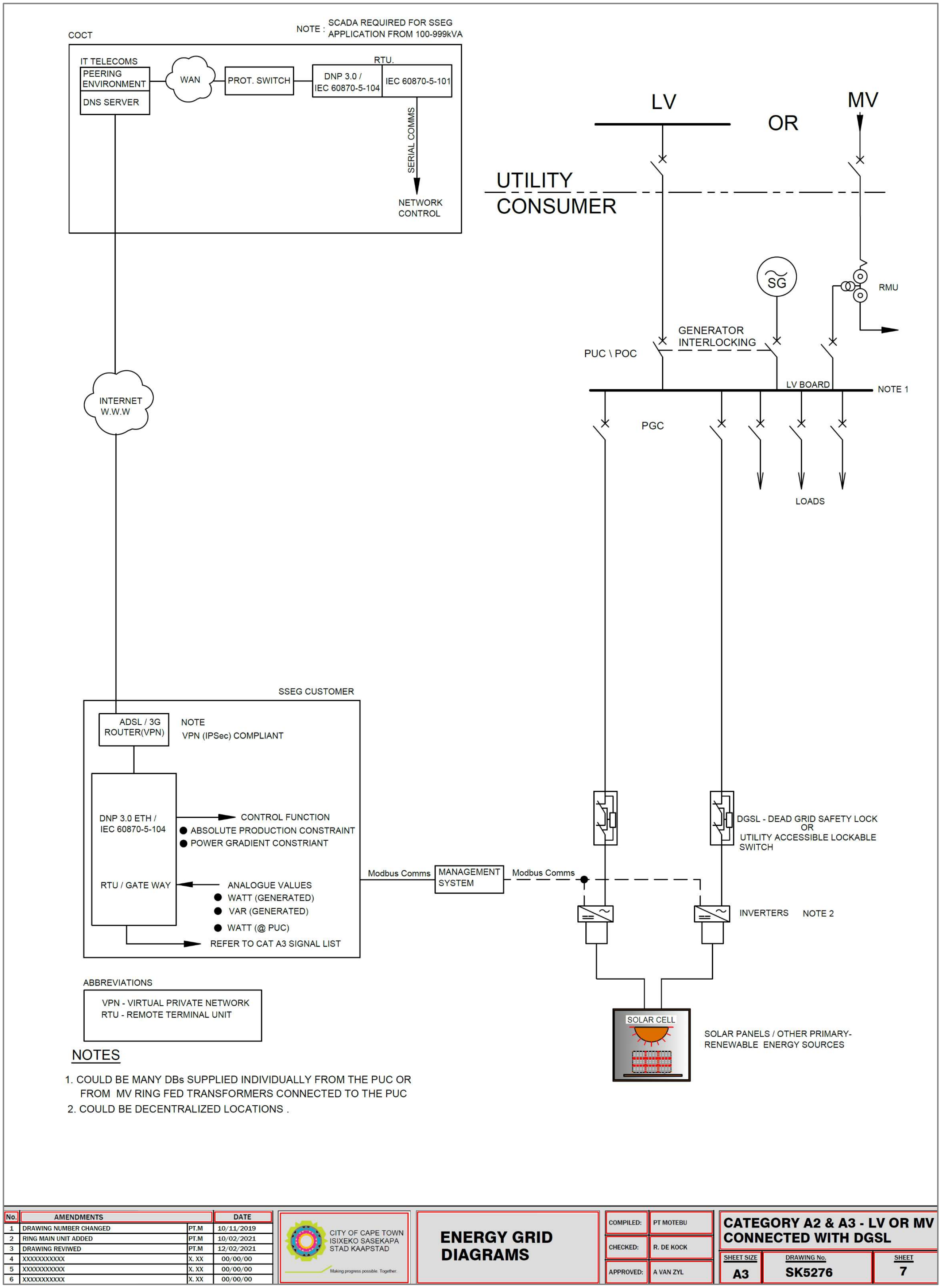
SK5276 Sheet 3: Grid-tied with storage



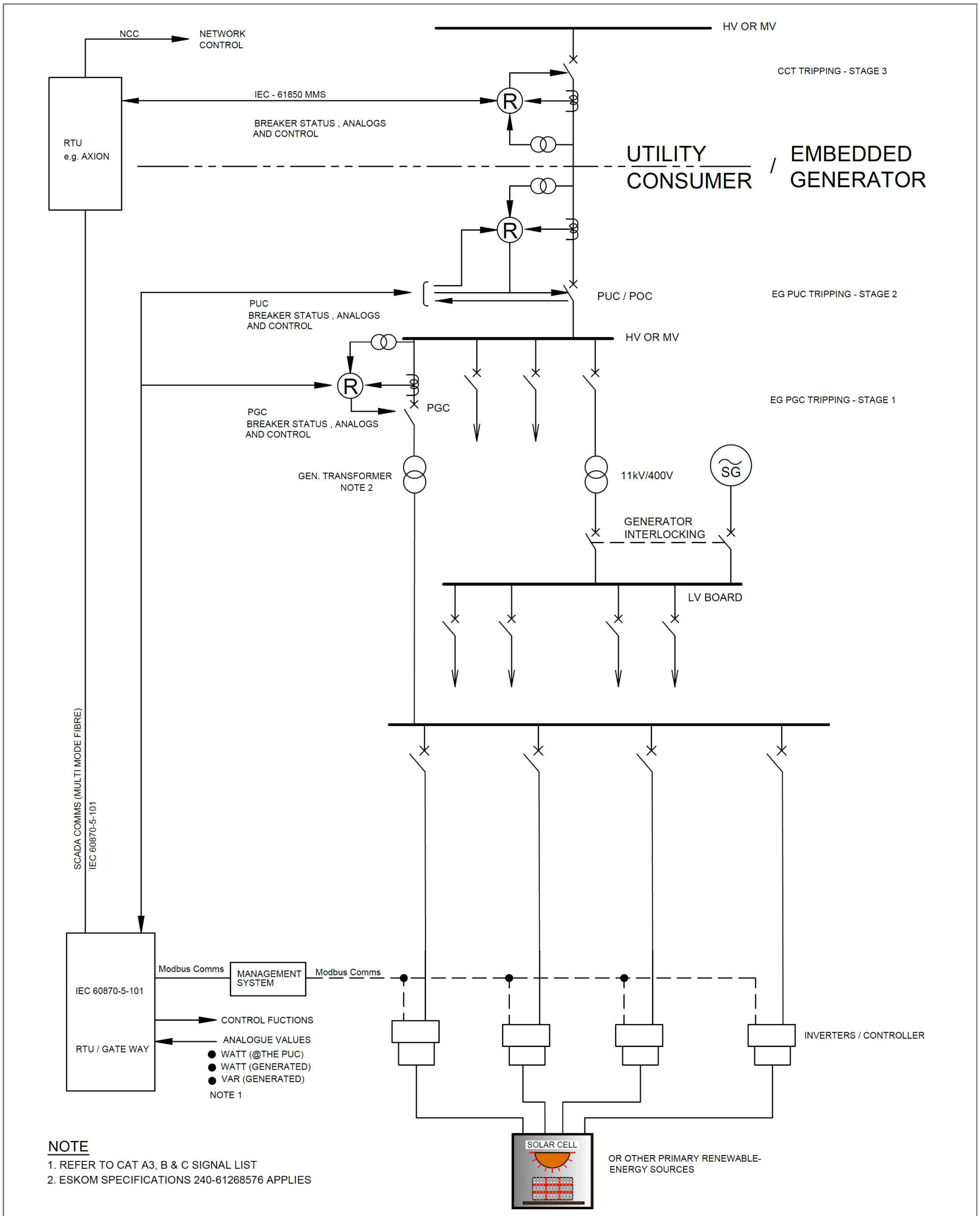
SK5276 Sheet 6: Category A2 and A3 - LV or MV connection with CDD



SK5276 Sheet 7: Category A2 and A3 - LV or MV connection with DGSL



SK5276 Sheet 8: Medium and High Voltage Embedded Generation



NOTE

1. REFER TO CAT A3, B & C SIGNAL LIST
2. ESKOM SPECIFICATIONS 240-61268576 APPLIES

No.	AMENDMENTS		DATE
1	DRAWING NUMBER CHANGED	PT.M	10/11/2020
2	DRAWING REVIEWED	PT.M	04/02/2021
3	DRAWING REVIWED	PT.M	12/02/2021
4	DRAWING REVIWED	PT.M	24/01/2022
5	XXXXXXXXXXX	X. XX	00/00/00
6	XXXXXXXXXXX	X. XX	00/00/00

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ENERGY GRID DIAGRAMS

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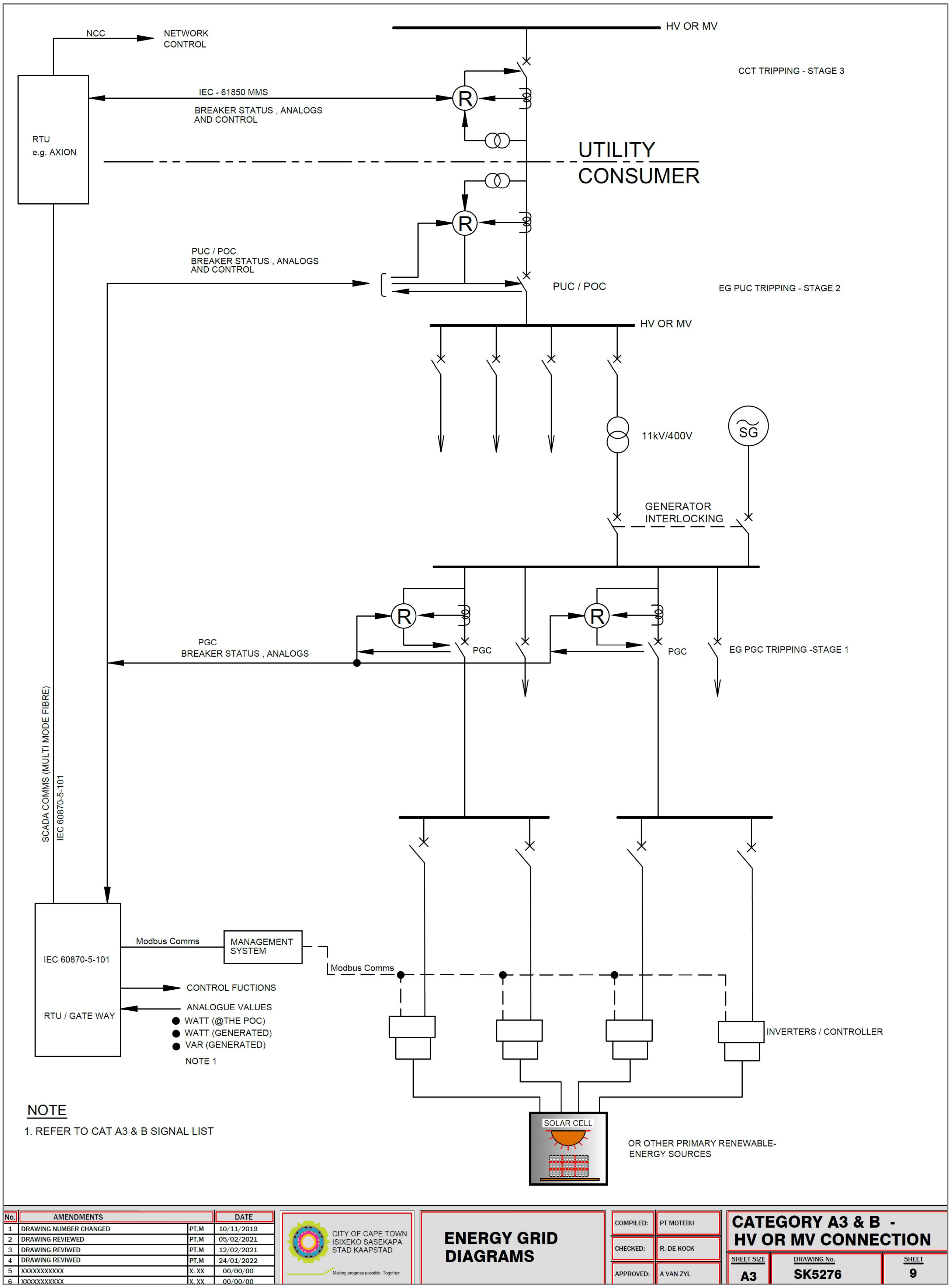
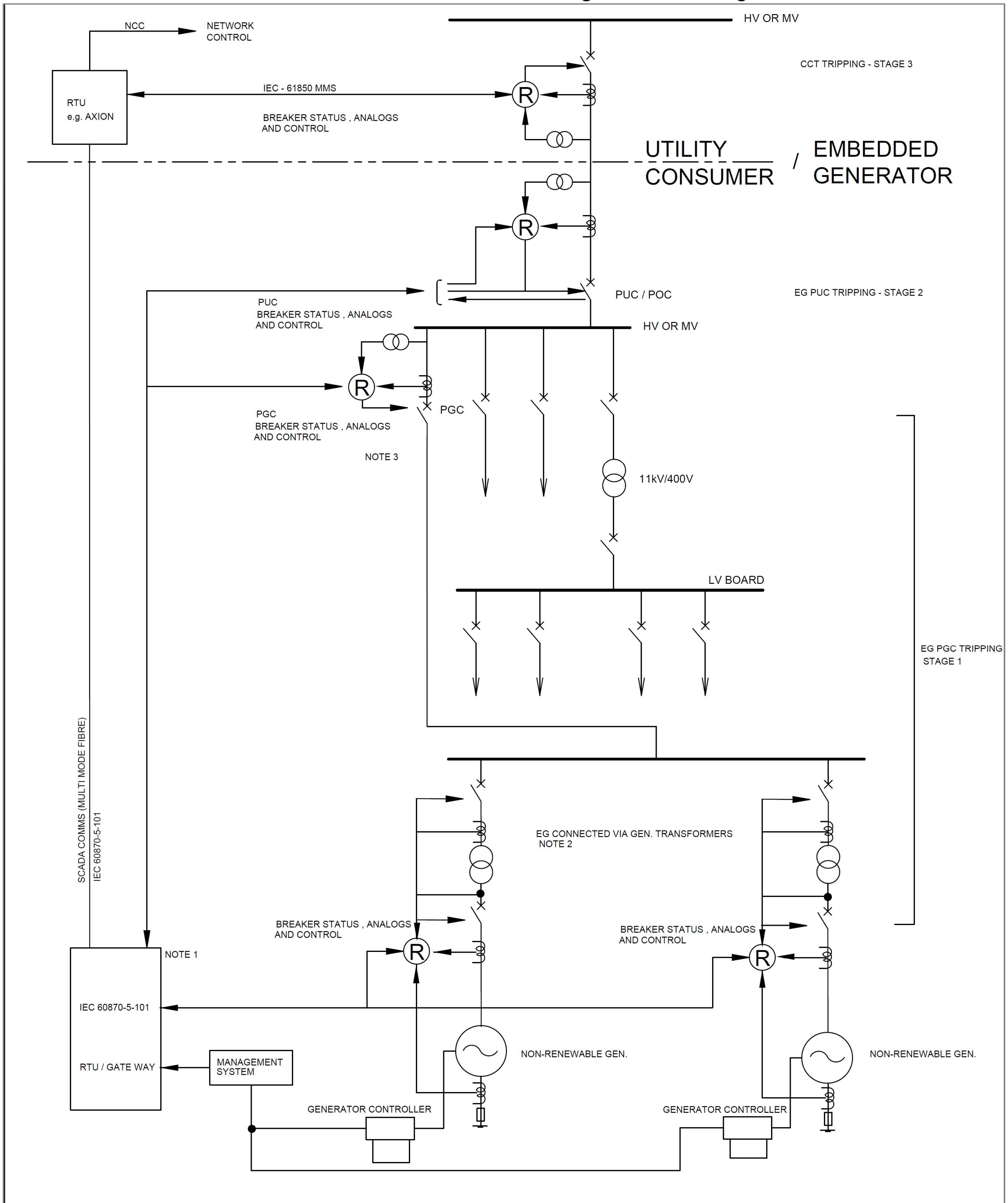
MEDIUM AND HIGH VOLTAGE CONNECTION

SHEET SIZE	DRAWING No.	SHEET
A3	SK5276	8

SK5276 Sheet 9: Category A3 & B - MV or HV connection



SK5276 Sheet 10: Non-renewable embedded generator with gen transformer



NOTE

1. SCADA SIGNALS AS PER EEB705
2. ESKOM SPECIFICATION 240-61268576 APPLIES
3. PGC TO BE SINGLE OR MULTIPLE GENERATORS, OR GENERATORS TO MULTIPLE PGC CONNECTIONS .

No.	AMENDMENTS		DATE
1	DRAWING SHEET 10 ADDED	PT.M	05/01/2022
2	DRAWING REVIWED	PT.M	24/01/2022
3	XXXXXXXXXXX	X. XX	00/00/00
4	XXXXXXXXXXX	X. XX	00/00/00
5	XXXXXXXXXXX	X. XX	00/00/00
6	XXXXXXXXXXX	X. XX	00/00/00

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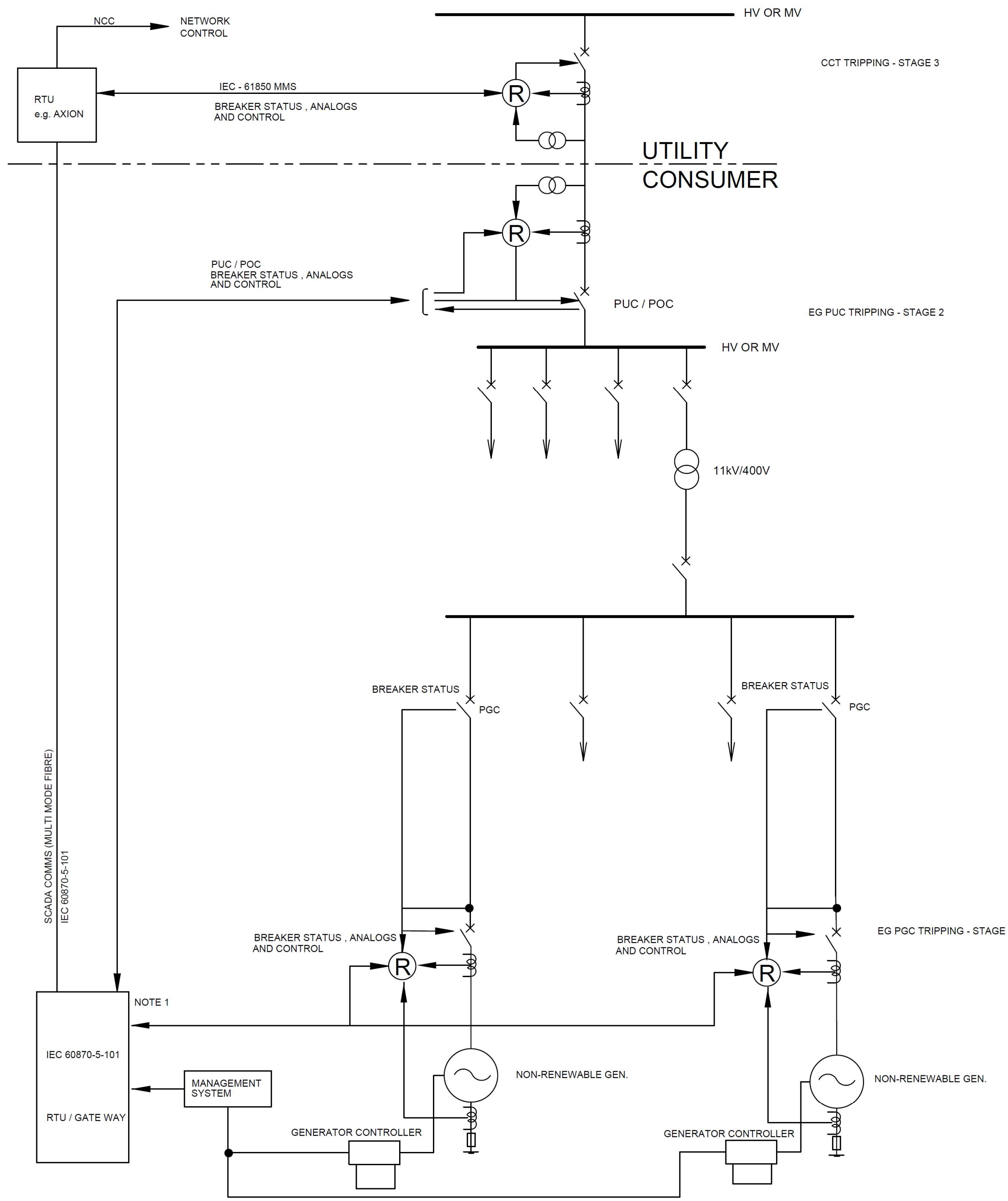
NON RENEWABLE GENERATOR (GENERATOR TRANSFORMER)

SHEET SIZE	DRAWING No.	SHEET
A3	SK5276	10

SK5276 Sheet 11: Non-renewable embedded generator – LV embedded



NOTE

1. SCADA SIGNALS AS PER EEB705

No.	AMENDMENTS		DATE
1	DRAWING SHEET 10 ADDED	PT.M	05/01/2022
2	DRAWING REVIWED	PT.M	24/01/2022
3	XXXXXXXXXXX	X. XX	00/00/00
4	XXXXXXXXXXX	X. XX	00/00/00
5	XXXXXXXXXXX	X. XX	00/00/00
6	XXXXXXXXXXX	X. XX	00/00/00

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD
Making progress possible. Together.

ENERGY GRID DIAGRAMS

COMPILED:	PT MOTEBU
CHECKED:	R. DE KOCK
APPROVED:	A VAN ZYL

NON RENEWABLE GENERATOR (LV EMBEDDED)

SHEET SIZE	DRAWING No.	SHEET
A3	SK5276	11

Appendix B: SCADA Interface

1. SSEG Cat A3 PLANT DNP3_SCADA_INTERFACE

version revision ref. SSEG Plant DNP3_SCADA_INTERFACE_2022_01_31.xlsx

TELECONTROL PROTOCOL MAPPING FOR A DNP3 LAN SERVER INTERFACE BETWEEN A SCADA CLIENT AND AN EMBEDDED GENERATION PV INSTALLATION(SSEG CATEGORY A3 - >100kVA to <1MVA-Renewable PV Power Plant)

COMMUNICATION DRECTION	SELECTABLE RANGE(UNIT)	SCADA Master TAG DESCRIPTION	PROTOCOL SPECIFIC TELEGRAM TYPE TO CONFIGURE							
			DNP3 ADDRESS	OUTPUT TYPE	EVENT CLASS	CONTROL direction object	variation		object	variation
Set point from Client	% 0 - 100% (integer value -for example, 25)	Production Constraint of Generated AC Power (100% production is max declared generation capacity)	0	16 bit Analog control	0	41	2		40	2
Set point from Client	5%,10%,15%/minute +	Power Gradient Constraint (Ramp up rate)	1	16 bit Analog control	0	41	2		40	2
Set point from Client	5%,10%,15%/minute -	Power Gradient Constraint (Ramp down rate)	2	16 bit Analog control	0	41	2		40	2
Control functions are configured for select before operate										
			DNP3 ADDRESS	INPUT TYPE	EVENT CLASS General interrogation	STATIC object	variation	EVENT CLASS	EVENT CHANG object	variation
Feedback from Server	Watts	Total Power Generated by *EG Plant	0	32 bit Analog input	0	30	5	2	32	7
Feedback from Server	Var	Total Reactive Power Generated by *EG Plant	1	32 bit Analog input	0	30	5	2	32	7
Feedback from Server	+Watts Exported or - Watts /Imported	Exported Power/ Imported Power - measurement @ *POC of EG Plant	2	32 bit Analog input	0	30	5	2	32	7
Feedback from Server	% 0 - 100% (integer representing the % set point -last updat	Production Constraint of Generated Power(confirmation of last received % set point value echo)	3	16 bit Analog input	0	30	4	2	32	4
Feedback from Server	5%,10%,15%/minute	Power Gradient Constraint UP(confirmation of last received Ramp Up % set point value echo)	4	16 bit Analog input	0	30	4	2	32	4
Feedback from Server	5%,10%,15%/minute	Power Gradient Constraint DOWN(confirmation of last received Ramp Down % set point value echo)	5	16 bit Analog input	0	30	4	2	32	4
Feedback from Server	ON/OFF (alarm condition = OFF - bit set high =1)	Production Constraint Mode Function selection (ON/OFF)	0	binary input status/change with tim	0	1	2	1	2	2
Feedback from Server	ON/OFF (alarm condition = OFF - bit set high =1)	Power Gradient Constraint Mode Function selection (ON/OFF)	1	binary input status/change with tim	0	1	2	1	2	2
client/ server addressing for compliance testing	**DNP3 Client address: 100**	**DNP3 Server address: 101 (for compliance test purposes only-final address will be provided in due course)**		**IPV4 Address of server: to be provided by installer for compliance test purposes only. Final TCPIP configuration parameters will be provided in due course**					**Port #: 20000**	

The City of Cape Town Municipality will provide the final source and destination addressing of the DNP3 server/client as well as the VPN configuration settings for each SSEG sites TCPIP connection to the SCADA Master Station in due course.

*NOTES EG = EMBEDDEED GENERATION and POC + POINT OF CONNECTION to the CoCT electricity supply network

DNP 3 Object and Variation definition list used for interoperability with the City of Cape Town SSEG SCADA interface (SEL3530-4 Real Time Automation Controller)

Monitoring Direction (Server to Client)

Object	Variation	Definition
30	4	16 bit Analog Input Without quality flag (Static)
	5	32 bit Analog Input short floating point With quality flag (Event Change)
32	4	16 bit Analog Input Event With quality flag and Time stamped (Static)
	7	32 bit Analog Input short floating Event With quality flag and Time stamped (Event Change)
1	2	Binary Input With Flag(Static)
2	2	Binary Input Event change with Time(Event Change)
40	2	:16 bit Analogue Output Status
41	2	16 bit Analogue Output Block

Control Direction (Client to Server)

Object	Variation	Definition
40	2	16 bit Analogue Output Status
41	2	16 bit Analogue Output Block

2. SSEG Cat A3 PLANT IEC*-104/101 SCADA_INTERFACE

version revision ref. SSEG Plant IEC104_SCADA_INTERFACE_2022_01_31.xlsx

TELECONTROL PROTOCOL MAPPING FOR A IEC 60870-5-104 SERVER INTERFACE BETWEEN A SCADA CLIENT AND AN EMBEDDED GENERATTION PV INSTALLATION(CATEGORY A3 - 100kVA to 1MVA-Renewable PV Power Plant)

COMMUNICATION DRECTION	SELECTABLE RANGE(UNIT)	SCADA Master TAG DESCRIPTION	PROTOCOL SPECIFIC TELEGRAM TYPE TO CONFIGURE			
			Telegram Type ID	CONTROL DIRECTION TYPE	Telegram Type	INFORMATION OBJECT ADDRESS
Set point from Client	% 0 - 100% (integer value -for example, 25)	Production Constraint of Generated AC Power (100% production is max declared generation capacity)	<49>	Set point command -scaled value	C_SE_NB_1	4001
Set point from Client	5%,10%,15%/minute +	Power Gradient Constraint (Ramp up rate)	<49>	Set point command -scaled value	C_SE_NB_1	4002
Set point from Client	5%,10%,15%/minute -	Power Gradient Constraint (Ramp down rate)	<49>	Set point command -scaled value	C_SE_NB_1	4003
			Telegram Type ID	MONITORING DIRECTION TYPE TYPE	Telegram Type	INFORMATION OBJECT ADDRESS
Feedback from Server	Watts	Total Power Generated by *EG Plant	<13>	Measured value -short floating point value	M_ME_NC_1	3001
Feedback from Server	Vår	Total Reactive Power Generated by *EG Plant	<13>	Measured value -short floating point value	M_ME_NC_1	3002
Feedback from Server	+Watts Exported or -Watts /Imported	Exported Power/ Imported Power - measurement @ *POC of EG Plant	<13>	Measured value -short floating point value	M_ME_NC_1	3003
Feedback from Server	% 0 - 100% (integer representing the % set point -last update)	Production Constraint of Generated Power(confirmation of last received % set point value echo)	<35>	Measured value -scaled value with time tag CP56Time2a	M_ME_TE_1	3004
Feedback from Server	5%,10%,15%/minute +	Power Gradient Constraint UP(confirmation of last received Ramp Up % set point value echo)	<35>	Measured value -scaled value with time tag CP56Time2a	M_ME_TE_1	3005
Feedback from Server	5%,10%,15%/minute -	Power Gradient Constraint DOWN(confirmation of last received Ramp Down % set point value echo)	<35>	Measured value -scaled value with time tag CP56Time2a	M_ME_TE_1	3006
Feedback from Server	ON/OFF (alarm condition = OFF - bit set high =1)	Production Constraint Mode Function selection (ON/OFF)	<30>	Single point information with Time tag CP56Time2a	M_SP_TE_1	1001
Feedback from Server	ON/OFF (alarm condition = OFF - bit set high =1)	Power Gradient Constraint Mode Functions selection (ON/OFF)	<30>	Single point information with Time tag CP56Time2a	M_SP_TE_1	1002
client/ server addressing for compliance testing	**IEC104 Client address: 1**	**IEC104 Server ASDU address: 101 (for compliance test purposes only-final address will be provided in due course)**		**IPV4 Address of server: to be provided by installer for compliance test purposes only. Final TCPIP configuration parameters will be provided in due course)**		**port # 2404**

The City of Cape Town Municipality will provide the final Client and Server ASDU addressing of the IEC104 addressing field as well as the VPN configuration settings for each SSEG sites TCP-IP/VPN connection to the SCADA Master Station in due course.

*NOTES EG = EMBEDDEED GENERATION and POC + POINT OF CONNECTION to the CoCT electricity supply network

Application Layer

Transmission Mode for Application Data Mode1 (least significant octet first), according to Section 4.10of IEC 60870-5-104, is used exclusively in this companion standard.

The common address of ASDU size to be configured for 2 octets

The Information Object Address size to be configured for 3 octets

The cause of transmission to be configured for 1 octet

Length of APDU -Monitoring Direction Maximum length 253

Length of APDU -Control Direction Maximum length 253

3. SSEG Cat B PLANT IEC*-101 SCADA_INTERFACE

SCADA requirement specific to a RPP type (X = Required, n/a = Not Applicable)
mnbr = May not be required for this type of RPP, subject to agreement with SO or NSP
BA = By agreement with SO or NSP
C= Applicable to Category C RPP only

Power Plant (PP) type reference		
Appendix 1	Wind Power Plant	WPP
Appendix 2	PV Power Pant	PVPP
Appendix 3	Concentrated Solar Power Plant	CSPP
Appendix 4	Small Hydro PP	SHPP
Appendix 5	Landfill Gas Power Plar	LGPP
Appendix 6	Biomass Power Plant	BMPP
Appendix 7	Biogas Power Plant	BGPP

This document must be used in conjunction with the references to the SAGC Requirements for Renewable Power Plants Rev 3.0(Aug 2019)

Monitored Signals from SSEG - Category B & C

MONITORING DIRECTION (input to SCADA) acronyms	
POINT OF CONNECTION	POC
SINGLE POINT INPUT	SPI
DOUBLE POINT INPUT	DPI
ANALOGUE INPUT	AI

Category B : 1MVA to >20MVA

Category C : 20MVA or higher

Synchronous Generator				Inverter-based / Asynchronous Machines									IEC101(Serial) Information Object List				DNP3 (Serial) Data Object List				
													Information Object				Data Object				
CSPP	BMPP	LGPP	BGPP	PVPP	SHPP	WPP	SAGC Index	Grid Connection code signal list REF	TABLE reference	FUNCTIONAL DESCRIPTION	INPUT TYPE	Comments:	Address	Type ID	Telegram Type	TYPE DESCRIPTION	Address	Type	Variation	Event class	TYPE DESCRIPTION
BA	BA	BA	BA	BA	BA	BA	DI 5	#1(k)	A10-2	Plant islanded	SPI	YES -1 /NO -0 (Input required for plant that is allowed to Island by NSP/SO)	1001	2	M_SP_TA_1	Single-point information with time tag	0	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 6	#1(l)	A10-2	Plant shutdown	SPI	YES -1 /NO -0 (Yes = Shutdown) Also refer to Tables A10-11 (1)-(4)	1002	2	M_SP_TA_1	Single-point information with time tag	1	2	2	1	Binary Input change with Time
BA	BA	BA	BA	BA	BA	BA	DI 4	#1(m)	A10-2	Plant trip on loss of grid protection or islanded protection	SPI	YES -1 /NO -0 (Input NOT required for plant that is allowed to Island by NSP/SO)	1003	2	M_SP_TA_1	Single-point information with time tag	2	2	2	1	Binary Input change with Time
C	C	C	C	C	C	C	DI 21	#3(a)	A10-8	Frequency Response System mode status	SPI	(ON=1/OFF=0) refer to table 4 below	1004	2	M_SP_TA_1	Single-point information with time tag	3	2	2	1	Binary Input change with Time
C	C	C	C	C	C	C	DI22		A10-8	Frequency mode status	SPI	(Not ready=1 /Ready=0) refer to table 4 below	1005	2	M_SP_TA_1	Single-point information with time tag	4	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 23	#4(a)	A10-10	Curtailment mode status	SPI	(ON/OFF) Also refer to Table A10-11 (1)-(4) reaction to when stop command is sent	1006	2	M_SP_TA_1	Single-point information with time tag	5	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 24	#4(b)	A10-10	Curtailment in progress	SPI	(YES=1 NO=0) Refer to Table A10-11 (1)-(4) reaction to when stop command is sent	1007	2	M_SP_TA_1	Single-point information with time tag	6	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 25	#4(d)	A10-10	Curtailment mode state	SPI	(Not ready=1 /Ready=0) Also refer to Table A10-11(1)-(4) reaction to when stop command is sent	1008	2	M_SP_TA_1	Single-point information with time tag	7	2	2	1	Binary Input change with Time
C	C	C	C	C	C	C	DI 27	#4(e)& 11(7)	A10-15	P-delta constraint mode	SPI	(ON/OFF) refer to table 4 below	1009	2	M_SP_TA_1	Single-point information with time tag	8	2	2	1	Binary Input change with Time
C	C	C	C	C	C	C	DI 28	#4(g) & 11(7)	A10-15	P-delta mode	SPI	(Not ready=1 /Ready=0) refer to table 4 below	1010	2	M_SP_TA_1	Single-point information with time tag	9	2	2	1	Binary Input change with Time
mnbr	mnbr	mnbr	mnbr	x	mnbr	x	DI 29	#4(h) &11(7)	A10-18	Power gradient constraint mode status	SPI	(ON-1/OFF-0) REFERENCE item 11(6)	1011	2	M_SP_TA_1	Single-point information with time tag	10	2	2	1	Binary Input change with Time
mnbr	mnbr	mnbr	mnbr	x	mnbr	x	DI 30	#4(k) & 11(7)	A10-18	Power gradient constraint mode	SPI	(Not ready=1 /Ready=0) REFERENCE item 11(6)	1012	2	M_SP_TA_1	Single-point information with time tag	11	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 31	#5(a)	A10-21	Reactive power (Q)control mode status	SPI	(ON-1/OFF-0)	1013	2	M_SP_TA_1	Single-point information with time tag	12	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 32	#5(e)	A10-21	Reactive power(Q) control mode	SPI	(Not ready=1 /Ready=0)	1014	2	M_SP_TA_1	Single-point information with time tag	13	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 33	#5(f)	A10-24	Power factor control mode state	SPI	(ON/OFF)	1015	2	M_SP_TA_1	Single-point information with time tag	14	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 34	#5(i)	A10-24	Power factor control mode	SPI	(Not ready=1 /Ready=0)	1016	2	M_SP_TA_1	Single-point information with time tag	15	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 35	#5(j)	A10-27	Voltage control mode state	SPI	(ON/OFF) only by agreement with NSP or SO	1017	2	M_SP_TA_1	Single-point information with time tag	16	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 36	#5(m)	A10-27	Voltage control mode	SPI	(Not ready=1 /Ready=0) only by agreement with NSP or SO	1018	2	M_SP_TA_1	Single-point information with time tag	17	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 20		A10-3(b)	Station DC Fail	SPI	(Operated -1 /Reset -0)	1019	2	M_SP_TA_1	Single-point information with time tag	18	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 19		A10-3(b)	Charger Mains Fail	SPI	(Operated -1 /Reset -0)	1020	2	M_SP_TA_1	Single-point information with time tag	19	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 18		A10-3(a)	Scheme DC Supply Fail	SPI	(Operated -1 /Reset -0)	1021	2	M_SP_TA_1	Single-point information with time tag	20	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 16		A10-3(a)	Breaker SF6 Gas Non- Urgent	SPI	(Operated -1 /Reset -0)	1022	2	M_SP_TA_1	Single-point information with time tag	21	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 17		A10-3(a)	Scheme AC Supply Fail	SPI	(Operated -1 /Reset -0)	1023	2	M_SP_TA_1	Single-point information with time tag	22	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 15		A10-3(a)	Breaker SF6 Gas Urgent	SPI	(Operated -1 /Reset -0)	1024	2	M_SP_TA_1	Single-point information with time tag	23	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 3		A10-2	Earth Applied	SPI	(YES -1 /NO -0)	1025	2	M_SP_TA_1	Single-point information with time tag	24	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 14		A10-3(a)	Pole discrepancy	SPI	(Operated -1 /Reset -0)	1026	2	M_SP_TA_1	Single-point information with time tag	25	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 13		A10-3(a)	Protection Unhealthy	SPI	(Operated -1 /Reset -0)	1027	2	M_SP_TA_1	Single-point information with time tag	26	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 12		A10-3(a)	Protection Operation	SPI	(Operated -1 /Reset -0)	1028	2	M_SP_TA_1	Single-point information with time tag	27	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 11		A10-3(a)	Breaker Fail Trip	SPI	(Operated -1 /Reset -0)	1029	2	M_SP_TA_1	Single-point information with time tag	28	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 10		A10-3(a)	Breaker Unhealthy	SPI	(Operated -1 /Reset -0)	1030	2	M_SP_TA_1	Single-point information with time tag	29	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 9		A10-3(a)	Breaker Fail	SPI	(Operated -1 /Reset -0)	1031	2	M_SP_TA_1	Single-point information with time tag	30	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 1	#1(j)	A10-2	Supervisory switch status	DPI	(OFF -01/ON-10)	2001	4	M_DP_TA_1	Double-point information with time tag	31	2	2	1	Binary Input change with Time
x	x	x	x	x	x	x	DI 7	#1(h)	A10-2	Breaker status at the POC	DPI	(Opened -01/Closed-10)	2002	4	M_DP_TA_1	Double-point information with time tag	0	4	2	1	Double point input with time
x	x	x	x	x	x	x	DI 8	#1(i)	A10-2	Isolator status	DPI	(Opened -01/Closed-10)	2003	4	M_DP_TA_1	Double-point information with time tag	1	4	2	1	Double point input with time
x	x	x	x	x	x	x	DI26		A10-13	Generation State	DPI	(Generating-10/Shutdown01) Reference Table A10-11 and A10-12for reaction to start /stop commands DO4	2004	4	M_DP_TA_1	Double-point information with time tag	2	4	2	1	Double point input with time
x	x	x	x	x	x	x	DI 2		A10-2	Earth switch	DPI	(Opened -01/Closed-10)	2005	4	M_DP_TA_1	Double-point information with time tag	3	4	2	1	Double point input with time
x	x	x	x	x	x	x		additional input		Active Generated Power (MW -AC)	AI	Generated 3 Phase power of entire plant (added CCT requirement)	3001	13	M_ME_NC_1	Measured value, short floating point number	0	32	5	2	Short Floating point event change without time
x	x	x	x	x	x	x	AI 1	#1(a)	A10-4	Active Power Imported/Exported (-/+MW)	AI	at the POC -description changed from Actual sent-out (MW)	3002	13	M_ME_NC_1	Measured value, short floating point number	1	32	5	2	Short Floating point event change without time
x	x	x	x	x	x	x	AI 4	#1(b)	A10-4	Actual Ramp rate of the entire RPP	AI	%/min	3003	13	M_ME_NC_1	Measured value, short floating point number	2	32	5	2	Short Floating point event change without time
x	x	x	x	x	x	x	AI 2	#1(c)	A10-4	Reactive Power (Q) Import/Export (-/+Mvar)	AI	at the POC	3004	13	M_ME_NC_1	Measured value, short floating point number	3	32	5	2	Short Floating point event change without time
x	x	x	x	x	x	x	AI 3	#1(d)	A10-4	Current sent out Red Phase	AI	current at the POC	3005	13	M_ME_NC_1	Measured value, short floating point number	4	32	5	2	Short Floating point event change without time
							AI 3	#1(d)	A10-4	Current sent out White Phase	AI	current at the POC	3006	13	M_ME_NC_1	Measured value, short floating point number	5	32	5	2	Short Floating point event change without time
							AI 3	#1(d)	A10-4	Current sent out Blue Phase	AI	current at the POC	3007	13	M_ME_NC_1	Measured value, short floating point number	6	32	5	2	Short Floating point event change without time
x	x	x	x	x	x	x	AI 5	#1(e)	A10-4	Power Factor	AI	of the RPP	3008	13	M_ME_NC_1	Measured value, short floating point number	7	32	5	2	Short Floating point event change without time
x	x	x	x	x	x	x	AI 6	#1(f)	A10-4	Voltage sent out	AI	at the POC	3009	13	M_ME_NC_1	Measured value, short floating point number	8	32	5	2	Short Floating point event change without time
BA	BA	BA	BA	BA	BA	BA	AI 7	#1(g)	A10-4	Frequency	AI	generated energy (only required where Islanding is allowed)	3010	12	M_ME_TB_1	Measured value, scaled value with time tag	9	32	5	2	Short Floating point event change without time
x	x	x	x	x	n/a	x	AI 11	#2(c)	A10-5	Air temperature	AI	measured signal in °C (-20 to 50)	3011	12	M_ME_TB_1	Measured value, scaled value with time tag	10	32	5	2	Short Floating point event change without time
x	x	x	x	x	n/a	x	AI 12	#2(d)	A10-5	Air pressure	AI	measured signal in mbar (800-1400)	3012	12	M_ME_TB_1	Measured value, scaled value with time tag	11	32	5	2	Short Floating point event change without time
n/a	n/a	n/a	n/a	x	n/a	n/a	AI 15	#2(f)	A10-5	Diffuse Solar radiation	AI	(watts/m²)Reference Table A10-5	3013	13	M_ME_NC_1	Measured value, short floating point number	12	32	5	2	Short Floating point event change without time
x	x	x	x	x	x	x	AI 16	A10-5	A10-5	Humidity	AI	(%)Reference Table A10-5	3014	12	M_ME_TB_1	Measured value, scaled value with time tag	13	32	4	2	16-Bit Analog Change Event with Time
n/a	n/a	n/a	n/a	n/a	n/a	x	AI 10	#2(b)	A10-5	Wind Direction	AI	0-359° from true north (within 75% of hub height)Reference Table A10-5	3015	12	M_ME_TB_1	Measured value, scaled value with time tag	14	32	4	2	16-Bit Analog Change Event with Time
n/a	n/a	n/a	n/a	n/a	n/a	x	AI 9	#2(a)	A10-5	Wind Speed	AI	meter/second (within 75% of hub height)	3016	13	M_ME_NC_1	Measured value, short floating point number	15	32	5	2	Short Floating point event change without time
n/a	n/a	n/a	n/a	n/a	n/a	x	AI 13	#2(e)	A10-5	Air Density	AI	(kg/m³)	3017	13	M_ME_NC_1	Measured value, short floating point number	16	32	5	2	Short Floating point event change without time
n/a	n/a	n/a	n/a	x	n/a	n/a	AI 14	#2(g)	A10-5	Direct Solar radiation	AI	(watts/m²)	3018	13	M_ME_NC_1	Measured value, short floating point number	17	32	5	2	Short Floating point event change without time
x	x	x	x	x	x	x	AI 17	#4(c)	A10-11	Active Power Curtailment setpoint feedback	AI	0 - 100% of Max Systems Production AC (refer to table A10-11 (1)-(4) reaction to when stop command is sent)	3019	12	M_ME_TB_1	Measured value, scaled value with time tag	18	32	4	2	16-Bit Analog Change Event with Time
C	C	C	C	C	C	C	AI 18	#4(f)	A10-16	P-delta setpoint feedback	AI	(% value) Refer to A10.6.3.2 & TABLE 4	3020	14	M_ME_TC_1	Measured value, short floating point number with time Tag	19	32	7	2	Short Floating point event change with Time
x	x	x	x	x	x	x	AI 19	#4(i)	A10-19	Up Ramp rate setpoint feedback	AI	0 - 100%/min of Max Systems Production AC (MW/Min)	3021	12	M_ME_TB_1	Measured value, scaled value with time tag	20	32	4	2	16-Bit Analog Change Event with Time
x	x	x	x	x	x	x	AI 20	#4(j)	A10-19	Down Ramp rate setpoint feedback	AI	0 - 100%/min of Max Systems Production AC (MW/Min)	3022	12	M_ME_TB_1	Measured value, scaled value with time tag	21	32	4	2	16-Bit Analog Change Event with Time
x	x	x	x	x	x	x	AI 21	#5(c)	A10-22	Reactive power (Q)lower limit	AI	Q capacitive limit(+) baes on plant availability	3023	14	M_ME_TC_1	Measured value, short floating point number with time Tag	22	32	7	2	Short Floating point event change with Time
x	x	x	x	x	x	x	AI 22	#5(d)	A10-22	Reactive power (Q)upper limit	AI	Q inductive limit(-) baes on plant availability	3024	14	M_ME_TC_1	Measured value, short floating point number with time Tag	23	32	7	2	Short Floating point event change with Time
x	x	x	x	x	x	x	AI 23	not specified	A10-22	Reactive Power (Q)setpoint feedback	AI	knar or Mvar (Production+/Absorption-) command DO8 or AO5	3025	14	M_ME_TC_1	Measured value, short floating point number with time Tag	24	32	7	2	Short Floating point event change with Time
x	x	x	x	x	x	x	AI 24	#5(h)	A10-25	Power factor control setpoint feedback	AI	(command DO10 or AO6)	3026	14	M_ME_TC_1	Measured value, short floating point number with time Tag	25	32	7	2	Short Floating point event change with Time
BA	BA	BA	BA	BA	BA	BA	AI 25	#5(l)	A10-28	Voltage control mode setpoint feedback	AI	only by agreement with NSP or SO (Command DO12 or A07)	3027	14	M_ME_TC_1	Measured value, short floating point number with time Tag	26	32	7	2	Short Floating point event change with Time

SCADA requirement specific to a RPP type (X = Required, n/a = Not Applicable)
mnbr = May not be required for this type of RPP, subject to agreement with SO or NSP
BA = By agreement with SO or NSP
C= Applicable to Category C RPP only

Power Plant (PP) type reference		
Appendix 1	Wind Power Plant	WPP
Appendix 2	PV Power Pant	PVPP
Appendix 3	Concentrated Solar Power Plant	CSPP
Appendix 4	Small Hydro PP	SHPP
Appendix 5	Landfill Gas Power Plan	LGPP
Appendix 6	Biomass Power Plant	BMPP
Appendix 7	Biogas Power Plant	BGPP

Control signals sent to SSEG Category B

Description of acronyms used	
SINGLE COMMAND OUTPUT	SCO
DOUBLE COMMAND OUTPUT	DCO
ANALOGOGE SETPOINT OUTPUT	ASO

Category B : 1MVA to 20MVA

Synchronous Generator				Inverter-based / Asynchronous Machines								
CSPP	BMPP	LGPP	BGPP	PVPP	SHPP	WPP	SAGC Index	Grid Connection code signal list REF	TABLE reference	FUNCTIONAL DESCRIPTION	CONTOL TYPE	Comments:
x	x	x	x	x	x	x	DO 1	13.3(a)	A10-6	Circuit Breaker (Trip - no close)	DCO	Open-01 ONLY (Isolate the RPP from the grid)
BA	BA	BA	BA	BA	BA	BA	DO 4	13.3(e)	A10-11/12	Generation state Start/Stop command	DCO	(Start-10/Stop-01)(AI 17 &DI 26)
BA	BA	BA	BA	BA	BA	BA	DO 8	#5(b)	A10-20	Reactive Power (Q)control setpoint raise/lower	DCO	(Raise-01/Lower-10) or Command AO5
BA	BA	BA	BA	BA	BA	BA	DO 10	#5(g)	A10-23	Power factor control setpoint raise/lower	DCO	(Raise-01/Lower-10) or Command AO6
BA	BA	BA	BA	BA	BA	BA	DO 12	#5(k)	A10-26	Voltage control setpoint raise/lower	DCO	(Raise-01/Lower-10)or Command AO7
C	C	C	C	C	C	C	DO 2	13.3(b)	A10-7	Primary frequency control ON/OFF	SCO	(ON-1/OFF-0)only by agreement with NSP or SE
x	x	x	x	x	x	x	DO 3	13.3(c)	A10-9	Curtailment mode ON/OFF	SCO	(ON-1/OFF-0)
C	C	C	C	C	C	C	DO 5	13.3(f)	A10-14	P-delta constraint mode ON/OFF	SCO	(ON-1/OFF-0)
mnbr	mnbr	mnbr	mnbr	x	mnbr	x	DO 6	13.3(h)	A10/20	Power gradient constraint ON/OFF	SCO	(ON-1/OFF-0) Refer to item 11(6)
x	x	x	x	x	x	x	DO 7	13.3(k)	A10-20	Reactive Power (Q)control mode ON/OFF	SCO	(ON-1/OFF-0)
x	x	x	x	x	x	x	DO 9	13.3(m)	A10-23	Power factor mode ON/OFF	SCO	(ON-1/OFF-0)
x	x	x	x	x	x	x	DO 11	13.3(o)	A10-26	Voltage control mode ON/OFF	SCO	(ON=1/not OFF)only by agreement with NSP or SE
x	x	x	x	x	x	x	AO 1	13.3(d)	A10-9	Curtailment setpoint command	ASO	0 - 100% of Max Systems Production AC (Active power)
C	C	C	C	C	C	C	AO 2	13.3(g)	A10-14	P-delta setpoint command	ASO	% Refer to A10.6.3.2
mnbr	mnbr	mnbr	mnbr	x	mnbr	x	AO 3	13.3(i)	A10-17	Up ramp rate setpoint command	ASO	0 - 100%/min of Max Systems Production AC Refer to item 11(6)
mnbr	mnbr	mnbr	mnbr	x	mnbr	x	AO 4	13.3(j)	A10-7	Down ramp rate setpoint command	ASO	0 - 100%/min of Max Systems Production AC & Refer to item 11(6)
BA	BA	BA	BA	BA	BA	BA	AO 5	13.3(l)	A10-20	Reactive power control (Q)setpoint command or DO8	ASO	(kvar or Mvar)Producing vars+/ Absorbing vars- Note 1 below
BA	BA	BA	BA	BA	BA	BA	AO 6	13.3(n)	A10-23	Power factor setpoint command or DO10	ASO	Note 1 below
BA	BA	BA	BA	BA	BA	BA	AO 7	13.3(p)	A10-26	Voltage control setpoint or DO12	ASO	only by agreement with NSP or SE Note 1 below

SAGC Index	IEC101/IEC104 Information Object List: Information Object Address	Type ID	Telegram Type	TYPE DESCRIPTION	DNP3 Serial/DNP3 Ethernet: Data Object Address	Type	Variation	Event class	TYPE DESCRIPTION
DO 1	4001	46	C_DC_NA_1	Double command(select before operate)	0	10	2	0	Double command(select before operate)
DO 4	4002	46	C_DC_NA_1	Double command(select before operate)	1	10	2	0	Double command(select before operate)
DO 8	4003	46	C_DC_NA_1	Double command(select before operate)	2	10	2	0	Double command(select before operate)
DO 10	4004	46	C_DC_NA_1	Double command(select before operate)	3	10	2	0	Double command(select before operate)
DO 12	4005	46	C_DC_NA_1	Double command(select before operate)	4	10	2	0	Double command(select before operate)
DO 2	4006	45	C_SC_NA_1	Single command(select before operate)	0	10	2	0	Single command(select before operate)
DO 3	4007	45	C_SC_NA_1	Single command(select before operate)	1	10	2	0	Single command(select before operate)
DO 5	4008	45	C_SC_NA_1	Single command(select before operate)	2	10	2	0	Single command(select before operate)
DO 6	4009	45	C_SC_NA_1	Single command(select before operate)	3	10	2	0	Single command(select before operate)
DO 7	4010	45	C_SC_NA_1	Single command(select before operate)	4	10	2	0	Single command(select before operate)
DO 9	4011	45	C_SC_NA_1	Single command(select before operate)	5	10	2	0	Single command(select before operate)
DO 11	4012	45	C_SC_NA_1	Single command(select before operate)	6	10	2	0	Single command(select before operate)
AO 1	5001	49	C_SE_NB_1	Scaled Value setpoint command	0	40	2	0	Scaled Value setpoint command
AO 2	5002	50	C_SE_NC_1	Short floating point Value setpoint command	1	40	1	0	Short floating point Value setpoint command
AO 3	5003	49	C_SE_NB_1	Scaled Value setpoint command	2	40	2	0	Scaled Value setpoint command
AO 4	5004	49	C_SE_NB_1	Scaled Value setpoint command	3	40	2	0	Scaled Value setpoint command
AO 5	5005	50	C_SE_NC_1	Short floating point Value setpoint command	4	40	1	0	Short floating point Value setpoint command
AO 6	5006	50	C_SE_NC_1	Short floating point Value setpoint command	5	40	1	0	Short floating point Value setpoint command
AO 7	5007	50	C_SE_NC_1	Short floating point Value setpoint command	6	40	1	0	Short floating point Value setpoint command

Referenced from Grid connection code for RPPs in South Africa Version 3.0

13.4 Communications Specifications

13.4.1 Gateway

(1) The Gateway shall be located in the RPP control room. The Gateway shall be owned, operated and maintained by the RPP generator.

(2) The Gateway shall be compatible with the SCADA Master Station protocols as per 13.4.2.1 and shall be tested as per the process described in Appendix 11.

(3) In the event of any proposed modification to the RPP plant control system which may affect the operation and functionality of the Gateway, the RPP generator shall follow the test process described in Appendix 11.

(4) The Gateway shall have at least three communication ports available exclusively for NSP and SO SCADA Master station communications.

13.4.2 Protocols for Information Exchange

(1) Only the IEC/IEEE protocols as specified below in 13.4.2.1 shall be used for SCADA information exchange between the RPP and the Gateway and the NSP or SO.

(2) The RPP control system shall be capable of reliably exchanging system status and data with the NSP or SO via the Gateway. The RPP shall cater for the communication infrastructure to connect the required number of Gateway ports to the NSP or TNSP telecommunications infrastructure in the NSP or TNSP substation.

Table 4: Control functions required for RPPs

Control function	Category A3	Category B	Category C
Frequency control	-	-	X
Absolute production constraint	X	X	X
Delta production constraint	-	-	X
Power gradient constraint	X	X	X
Q control	-	X	X
Power factor control	-	X	X
Voltage control	-	X	X

13.4.2.1 SCADA Protocol between the Gateway and the NSP or SO

(1) The IEC 60870-5-101 protocol shall be implemented on the Gateway for communication between the RPP and SO when the RPP connects to the Transmission System.

(2) The DNP3 protocol shall be implemented on the Gateway for communication between the RPP and NSP when the RPP connects to the Distribution System.

13.4.2.2 SCADA Protocols within the RPP system

(1) The RPP generator may select protocols for communication within the RPP plant control system which shall use GPS based time stamping for all digital signals at the Intelligent Electronic Device (IED) or plant controller level(if IED is not applicable) which will be propagated to the SCADA master station with date and time to 1 millisecond accuracy in the defined protocol as per 13.4.2.1

(2) The RPP generator shall ensure that the data propagated to the SCADA master station has the data quality flags set by the IED or plant controller (if IED is not applicable) from which the data originated.

Note 1

A10.6.4 Reactive Power, Power factor and Voltage Control Functions

(1) The reactive power, power factor and voltage control functions are mutually exclusive, which means that only one of the three functions mentioned below can be active at a time. At least one of these functions must be active.

(a) Reactive Power Control (Q control)

(b) Power Factor control (PF Control)

(c) Voltage control (V Control)

(2) The NSP or SO will select the relevant mode and change the setpoint. The RPP shall deactivate the other two modes. The setpoint feedback shall be updated within 2 seconds. The generator shall respond to the new setpoint within 30 seconds after receipt of an order to change to the new setpoint

11. Active Power Constraint Functions

(6) Delta productions constraint and power gradient constraint functions may not be required for CSP, SHPP, LGPP,BMPP and BGP 's subject to agreement by the SO or NSP.

4. NON RENEWABLE GENERATOR IEC*-101 SCADA INTERFACE

SCADA signal requirements list referenced to EEB 705 Section 8.2.3.6

Monitored Signals from Non-renewable Embedded Generation

MONITORING DIRECTION (input to SCADA) | **IEC101(Serial) Information Object List**

Description of acronym	acronym	
POINT OF CONNECTION	POC	
POINT OF UTILITY COUPLING	PUC	
POINT OF GENERATOR CONNECTION	PGC	
DOUBLE POINT INPUT	DPI	4 position states _ 00 (undefined), 01 (Open),10 (Closed_) & 11(error/intermediate
ANALOGUE INPUT	AI	Scaled -15bit plus sign or Short floating Point - 31 bit plus sign

FUNCTIONAL DESCRIPTION	INPUT TYPE	Comments:	Information Object: Address	Information Object: Type ID	Information Object: Telegram Type	TYPE DESCRIPTION
Breaker status at the POC/PUC	DPI	(Opened -01/Closed-10)	2001	4	M_DP_TA_1	Double-point information with time tag
Isolator status at the POC/PUC	DPI	(Opened -01/Closed-10)	2011	4	M_DP_TA_1	Double-point information with time tag
Earth Switch at the POC/PUC	DPI	(Opened -01/Closed-10)	2021	4	M_DP_TA_1	Double-point information with time tag
Breaker status at the PGC	DPI	(Opened -01/Closed-10)	2031	4	M_DP_TA_1	Double-point information with time tag
Isolator status at the PGC	DPI	(Opened -01/Closed-10)	2041	4	M_DP_TA_1	Double-point information with time tag
Earth Switch at the PGC	DPI	(Opened -01/Closed-10)	2051	4	M_DP_TA_1	Double-point information with time tag
Generation State	DPI	(Shut Down-01/Genrating-10)	2101	4	M_DP_TA_1	Double-point information with time tag
Active Power Imported/Exported (-/+MW)	AI	at the POC -(MW)	3001	13	M_ME_NC_1	Measured value, short floating point number
Power Gradient Ramp rate Up set point feedback	AI	0 - 100%/min of Max Systems Production AC (MW/Min)	3011	12	M_ME_TB_1	Measured value, scaled value with time tag
Power Gradient Ramp rate Down set point feedback	AI	0 - 100%/min of Max Systems Production AC (MW/Min)	3021	12	M_ME_TB_1	Measured value, scaled value with time tag

Configuration Note
Device description tags
Each circuit breaker, isolator and earth switch status that are
configured to report to the Network Control Centre will have
an unique tag description to identify the devise and location
in the EG system, with reference to that systems single line diagram
Protocol specific configuration
The IEC 101 Station address and ASDU address will be provided.
Station address length - 2 bytes
ASDU address length - 2 bytes
Information object address length -2 bytes
Cause of transmission length- 1 byte
The RTU will be configured to be poled for event changes
Analogue inputs shall have Zero dead bands configured
Serial communication configuration
baud rate - 19 200
parity - even
stop bits - none

If there are multiple inter connected circuits that form part of the EG System then the following shall apply

information object address assignment

Reported Switching Device Status	Object Address	Comment
Status of the 1st POC/PUC Circuit Breaker	2001	
Status of the second POC/PUC Circuit Breaker up to ten	2002-2010	If there are multiple POC/PUC connections, up to ten POC/PUC Circuit Breakers
Status of the 1st POC/PUC Isolator	2011	
Status of the second POC/PUC Isolator up to ten	2012-2020	If there are multiple POC/PUC connections, up to ten POC/PUC Isolators
Status of the 1st POC/PUC Earth switch	2021	
Status of the second POC/PUC Earth Switch up to ten	2022-2030	f there are multiple POC/PUC connections, up to ten POC/PUC Earth Switches
Status of the 1st PGC Circuit Breaker	2031	
Status of the second PGC Circuit Breaker up to ten	2032-2040	If there are multiple PGC connections , up to ten PGC Circuit Breakers
Status of the 1st PGC Isolator	2041	
Status of the second PGC Isolator up to ten	2042-2050	If there are multiple POC connections, up to ten PGC Isolators
Status of the 1st PGC Earth switch	2051	
Status of the second PGC Earth Switch up to ten	2052-2060	If there are multiple PGC connections, up to ten PGC Earth Switches
Status of 1st Generators State	2101	
Status of second Generators State up to ten	2102 -2110	If there are multiple Generator connections, up to ten Generators
Reported Analogue Values		
Active Power Imported/Exported Analogue value for the 1st Generator	3001	
Active Power Imported/Exported Analogue value for the second Generator up to ten	3002-3010	If there are multiple Generator connections, up to ten Generators
Up Ramp rate set point feedback Analogue value for the 1st Generator	3011	Power Gradient
Up Ramp rate set point feedback Analogue value for the second Generator up to ten	3012-3020	If there are multiple Generator connections, up to ten Generators
Down Ramp rate set point feedback Analogue value for the 1st Generator	3021	Power Gradient
Down Ramp rate set point feedback Analogue value for the second Generator up to ten	3022-3030	If there are multiple Generator connections, up to ten Generators

Appendix C: Protective relay type test requirements

(Normative)

Protective relays installed at the point of connection shall comply with the following international type test requirements.

Table C.1 — International standard type test requirements for protective relays

Item	Test	Standard	Test Level	Compliance Criteria
Auxiliary power supply				
1	Operating range		-	V_{Nom} – 20 % to V_{Nom} + 10 %.
2	Interruption	IEC 60255-11	-	For supply interruptions lasting less than 10ms, the device shall function as if no interruption had occurred.
3	A.C. ripple	IEC60255-11	-	Device shall function correctly with 12 % 100 Hz AC signal superimposed on the DC supply.
Power frequency magnetic field				
4	Steady State	SANS 61000-4-8	Class 4	30 A/m continuous, 300 A/m short duration, 50 Hz
Insulation resistance				
5	Dielectric withstand	IEC 60255-5	-	2 kV rms 50 Hz for 1 minute between all terminals to case earth. Transverse tests between contacts shall also be performed to the above specification.
6	Insulation resistance	IEC 60255-5	-	Insulation resistance greater than 20 MΩ when measured at 500 V dc
Environmental tests				
7	Cold	IEC 60068-2-1	-10°C or less	Operates within tolerance at -10 °C (LCD screen operative)
8	Dry Heat	IEC 60068-2-2	+55°C or more	Operates within tolerance at +55 °C
9	Cyclic Temperature and Humidity	IEC 60068-2-30	Test Db	25 °C and 95% relative humidity/ 55 °C and 95 % relative humidity, 12 + 12 hour cycle
10	Enclosure protection	SANS 60529	IP53	Protected against ingress of dust particles, spraying water
Mechanical tests				
11	Vibration	IEC 60255-21-1	Class 2 (response and endurance)	Response: 1g, 10 – 150 Hz, 1 sweep energised. Contacts should not close for longer than 2 ms. Endurance: 2 g 10 – 150 Hz, 20 sweeps, unenergised contacts should not close for longer than 2 ms.
12	Shock	IEC 60255-21-2	Class 1 (response and withstand)	Response: 5 g, 11 ms, 3 pulses in each direction, energised Withstand: 15 g, 11 ms, 3 pulses in each direction, unenergised
13	Bump	IEC 60255-21-2	Class 1	10 g, 16 ms, 1000 pulses unenergised.
14	Seismic	IEC 60255-21-3	Class 1	Test method A (single axis sine sweep test) 1 – 35 Hz, 1 sweep.

Table C.1 — International standard type test requirements for protective relays (*continued*)

Item	Test	Standard	Test Level	Compliance Criteria
Impulse tests				
15	Electrical impulse (1,2/50 μs)	IEC 60255-5	-	5 kV 1,2/50 μs waveform, 0,5 J
Electromagnetic compatibility				
16	1MHz Disturbance Burst	IEC60255-22-1 or SANS 61000-4-12	Class 3	2,5 kV common mode, 1kV differential mode, 2s total test duration, 6 – 10 bursts
17	Fast Transient	IEC 60255-22-4 or	Class A (IV)	4 kV, 2,5kHz 2 kV, 5 kHz on Comms ports
		SANS 61000-4-4	Class 4	4 kV, 5 kHz (power port) 2 kV, 5 kHz (I/O signal, data and control ports)
18	Electrostatic Discharge	IEC 60255-22-2 or SANS 61000-4-2	Class 3	6 kV Contact Discharge, 8 kV Air Discharge
19	Surge immunity	IEC 60255-22-5 or SANS 61000-4-5	- Class 3	2 kV
20	Radiated Radio Frequency EM field immunity	IEC 60255-22-3 or SANS 61000-4-3	- Class 3	10 V/m, 80 MHz – 1 GHz
21	Conducted Radio Frequency EM field immunity	IEC 60255-22-6 or SANS 61000-4-6	- Class 3	10 Vrms, 150 kHz – 80 MHz