Eskom	**Standard**	**Distribution**

Title: **EPC: FUNCTIONAL SPECIFICATION FOR A SOLAR PHOTOVOLTAIC AND BATTERY ENERGY STORAGE: ESKOM GAUTENG CLUSTER, CUSTOMER NETWORK CENTERS**

Unique Identifier:	**240 - D X - G P - 016T**
Alternative Reference Number:	**<n/a>**
Area of Applicability:	**Engineering**
Documentation Type:	**Standard**
Revision:	**2**
Total Pages:	**45**
Next Review Date:	**September 2027**
Disclosure Classification:	**Controlled Disclosure**

Compiled by	**Approved by**	**Authorized by**
Marius Jansen van Vuuren	**Kuno Rottcher**	**Ariseelan Moodley**
Design Engineer	**Asset Design Manager (Acting)**	**Network Planning Middle Manager**
Date: 2023/09/12	Date: 12 September 2023	Date: 12/09/2023

Content

Figures

Tables

1. Introduction

Gauteng Cluster's (GC) strategic objective is to install alternative energy sources at their Customer Network Centres in the form of a solar photovoltaic (PV) and Battery Energy Storage (BES), to reduce the impact on business operations during loadshedding. The preferred solution should allow the building to operate directly from the PV during the usable daylight hours (assumed to be 6 hours) and should have sufficient storage to power the building for the remainder of the day. Integration with existing supplies (Grid and Generator [if available]) and additional energy efficiency building services is essential.

Renewable systems and alternative energy supplies still carries a premium and hence the scope should be minimised as much as possible to avoid undue capital pressure expenditure. A quality installation seeks a fine balance between cost, time, and good design.

As such, it is proposed to prepare for the new system by:

- Reducing base load or supplying such load from alternative sources (other than PV and batteries)
- Prioritising critical load
- Providing an optimising PV and BES system

This functional specification will form part of an Engineering, Procure and Construction contract (EPC)

2. Supporting clauses

2.1 Scope

This document contains the functional requirements for an integrated PV and BES system for Eskom Gauteng Cluster (GC) Customer Network Centres.

2.1.1 Purpose

The purpose of the document is to provide verifiable system requirements of a PV and BES system.

2.1.2 Applicability

This document shall apply to the GC CNC's renewables projects only.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

None

2.2.2 Informative

[1] 240-103407540 Commissioning Standard for Embedded Generators in Low Voltage Installations

[2] 240-105658000 Supplier Quality Management Specification

[3] 240-109589380, Direct Lightning Stroke Protection of Substations

[4] 240-120804300 Standard for The Labelling of Electrical Equipment within ESKOM Wires Networks

[5] 240-150128782 Framework for Design Solutions to Connect Customer Owned SSEG's

[6] 240-152929508: Maximum Generation Limits on LV Networks – Category A1 to A3

[7] 240-170000103 Lithium iron phosphate batteries standard

[8] 240-170000521 Clarification of Small-Scale Embedded Generation Connection Criteria

[9] 240-170000777 Engineering Instruction for Operating LV Networks with Small Scale Embedded Generators (SSEG)

[10] 240-54937439 Fire Protection / Detection Assessment standard

[11] 240-54937450 Fire Protection and Life Safety Design standard

[12] 240-55410927 Cyber Security Standard for Operational Technology

[13] 240-56536505 Hazardous Locations Standard

[14] 240-57649065 LV Protection Standard (Draft)

[15] 240-57855874 Photovoltaic Modules and Regulators

[16] 240-61182045 Maintenance Engineering Standard for Batteries and Chargers

[17] 240-61227308: Network and Grid Planning Standard for Generation Grid Connection – Application for Planning Studies

[18] 240-61268576: Standard for the Interconnection of Embedded Generation

[19] 240-61523882: LV Operating Regulations

[20] 240-62629353 Specification for Panel Labelling Standard

[21] 240-62772907, Standard for Stationary Diesel Generator Systems

[22] 240-64038621 Remote Device Communication Standard for Data Retrieval and Remote Access

[23] 240-64636794 Generic Equipment Specification Wire, Wire Marking, Cable Numbering, Fibre Optical Cable Installation and Labelling

[24] 240-71630971 Dx Telecontrol: User Requirement Specification for Cellular-Based Communications

[25] 240-75655504 Corrosion Protection Standard for New Indoor and Outdoor Eskom Equipment, Components, Materials and Structures Manufactured from Steel Standard

[26] 240-75661043 Services Standard

[27] 240-79669677 Demilitarised Zone (DMZ) Designs for Operational Technology

[28] 240-81732810: Operating Guideline for Dedicated LV Networks with Embedded Generation

[29] 240-84924080: Metering Requirements for Small Scale Embedded Generation

[30] 240-91252455, Lighting for Perimeter Security at Eskom Installations

[31] 240-113163905, LED Floodlights for Distribution Substation Applications

[32] 240-97423211 - Network Engineering & Design – Design Drawing Guideline rev 2

[33] 32-373 Information security – IT/OT and third-party remote access standard

[34] BESF GC Grid Code Grid Connection Code for Battery Energy Storage Facilities (BESF) Connected to the Electricity Transmission System (TS) or the Distribution System (DS) In South Africa Version 5.2

[35] Grid connection code for Renewable Power Plants (RPPs) connected to the electricity Transmission system (TS) or the Distribution system (DS) in South Africa Version 3

[36] IEC 60068-2-78 - Environmental testing - Part 2-78: Tests - Test Cab: Damp heat steady state

[37] IEC 60364-6: Low Voltage Electrical Installations-Verification

[38] IEC 60364-7-712 - Electrical Installations of Buildings: Requirements for Special Installations or Locations – Solar Photovoltaic power supply systems

[39] IEC 60529 Degrees op protection provided by enclosures (IP Code)

[40] IEC 60751 Industrial platinum resistance thermometers and platinum temperature sensors

[41] IEC 60891 - Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics

[42] IEC 60904 Photovoltaic devices – all Parts

[43] IEC 61215-1 Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements

[44] IEC 61215-1-1 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules.

[45] IEC 61215-1-2 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-2: Special requirements for testing of thin-film cadmium telluride (CDTE) based Photovoltaic (PV) modules.

[46] IEC 61215-1-3 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-3: Special requirements for testing of thin-film amorphous silicon based photovoltaic (PV) Modules

[47] IEC 61215-1-4 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-4: Special requirements for testing of thin-film Cu (In, GA) (S, Se)2 based photovoltaic (PV) modules

[48] IEC 61215-2 Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 2: Test procedures

[49] IEC 6134 - UV test for photovoltaic (PV) modules

[50] IEC 61683: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency

[51] IEC 61701 - Photovoltaic (PV) modules - Salt mist corrosion testing

[52] IEC 61724-1 Photovoltaic system performance. Part 1: Monitoring standard

[53] IEC 61725: Analytical expression for daily solar profiles

[54] IEC 61727 - Photovoltaic (PV) systems - Characteristics of the utility interface

[55] IEC 61730-1 & 2 - Photovoltaic (PV) module safety qualification - Part 1 and 2

[56] IEC 61829 - Photovoltaic (PV) array - On-site measurement of current-voltage characteristics

[57] IEC 61853 - Photovoltaic (PV) module performance testing and energy rating

[58] IEC 62040 Uninterruptible power systems (UPS) – Parts 1 & 2

[59] IEC 62093 - Power conversion equipment for photovoltaic systems – Design qualification testing

[60] IEC 62109 Safety of Power Converters for use in photovoltaic power systems Part 1. 2 & 3

[61] IEC 62116 - Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures

[62] IEC 62446-1: Photovoltaic (PV) Systems-Requirements for testing, documentation, and maintenance-Part 1: Grid connected systems-Documentation, Commissioning tests and inspection

[63] IEC 62446-2: Photovoltaic (PV) Systems-Requirements for testing, documentation, and maintenance-Part 2: Grid connected systems-Maintenance of PV systems.

[64] IEC 62548 - Photovoltaic (PV) arrays - Design requirements

[65] IEC 62716 - Photovoltaic (PV) modules - Ammonia corrosion testing

[66] IEC 62619:2022 Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications

[67] IEEE 1547 Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

[68] IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems IEEE Std142-2007

[69] IEEE Power and Energy Society, IEEE Guide for Direct Lightning Stroke Shielding of Substations, IEEE Std 998-2012ISO 9060: solar energy - Specification and classification of instruments for measuring hemispherical solar and direct solar radiation.

[70] ISO 9845-1: solar energy - Reference solar spectral irradiance at the ground at different receiving conditions, Part 1: Direct normal and hemispherical solar irradiance for air mass 1.5.

[71] ISO 9847, solar energy - Calibration of field pyranometers by comparison to a reference pyranometer. / BS 7621: Method for calibrating field pyranometers by comparison to a reference pyranometer

[72] ISO/TR 9901: Solar energy - Field pyranometers – Recommended practice for use.

[73] NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations

[74] NFPA 855 Standard for the Installation of Stationary Energy Storage Systems

[75] NRS 048 – Electricity Supply - Quality of Supply

[76] NRS 048-Part 9 National Code of Practice: Load reduction practices, system restoration practices, and critical load and essential load requirements under system emergencies

[77] NRS 097-Part 2 Small-scale embedded generation

[78] Occupational Health and Safety Act No.85 of 1993 and Regulations, as amended.

[79] PD IEC TS 61724-2: Photovoltaic system performance. Part 2: Capacity evaluation method

[80] PD IEC/TS 61724-3: Photovoltaic system performance. Energy evaluation method

[81] SABS 0400-1990 – The application of the national building regulations

[82] SANS 10108 Classification of Hazardous Locations.

[83] SANS 10114-1: Interior lighting Part 1: Artificial lighting of interiors

[84] SANS 10114-2: Interior lighting Part 2: Emergency lighting

[85] SANS 10139 Code of practice for design, installation, commissioning and maintenance of fire detection and alarm systems in non-domestic premises

[86] SANS 10400 – The application of the National Building Regulations Part T: Fire Protection.

[87] SANS 10142-1 The wiring of Premises – Part 1: Low-voltage installations

[88] SANS 10162-1:2011 – Limit states design of hot rolled steelwork

[89] SANS 10198 Parts 1-14 The selection, handling, and installation of electric power cables of rating not exceeding 33 kV Part 1 to 14

[90] SANS 1041: Tubular fluorescent lamps for general service

[91] SANS 1088: Luminaire entries and spigots

[92] SANS 1091: National colour standard

[93] SANS 1200C – Site clearance

[94] SANS 1200DB – Earthworks (Pipe trenches)

[95] SANS 1200G – minor and major concrete works construction.

[96] SANS 1200M – Civil Engineering Construction Roads (general)

[97] SANS 1200MJ – All kinds of segmented paving

[98] SANS 1213 Mechanical Cable Glands

[99] SANS 1266: Ballasts for discharge lamps (excluding tubular fluorescent lamps)

[100] SANS 1411-2: Materials of insulated electric cables and flexible cords Part 2: Polyvinyl chloride (PVC).

[101] SANS 1431 – Weldable structural steel

[102] SANS 1507 Part 1: General - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)

[103] SANS 1507 Part 2: Wiring Cables - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)

[104] SANS 1507 Part 3: PVC Distribution cables - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)

[105] SANS 164: Plug and socket-outlet systems for household and similar purposes for use in South Africa

[106] SANS 50054 Fire detection and fire alarm systems

[107] SANS 60730-1: Automatic electrical controls - Part 1: General requirements

[108] SANS 60815 Selection and dimensioning of high-voltage insulators intended for use in polluted conditions

[109] SANS 61000-6-2, 3 and 4: Electromagnetic compatibility (EMC)

[110] SANS 61439 Low-voltage switchgear and control gear assemblies

[111] SANS 61641 Enclosed low-voltage switchgear and control gear assemblies

[112] SANS 61643-12: Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power systems

[113] SANS 62305-1 to 4 - Protection against lightning - Parts 1 to 4

[114] SANS 890: Ballasts for fluorescent lamps

[115] SANS 62305-1:2007, Protection against lightning: Part 1- General Principles

[116] SANS 62305-2:2007, Protection against lightning: Part 2- Risk Management

[117] SANS 62305-3:2007, Protection against lightning: Part 3- Physical damage to structures and life hazard

[118] SANS 62305-4:2007, Protection against lightning: Part 4- Electrical and electronic systems within structures

[119] SANS 62561:2013, Lightning protection system components

[120] SANS 10389-1, Exterior lighting, Part 1: Artificial lighting of exterior areas for work and safety

[121] TMH9 – Flexible Pavement management system

[122] TRH4: Structural design of flexible pavements for interurban and rural roads

[123] TRH7: The use of bitumen emulsions in the construction and maintenance of roads

[124] TUV *2pfg1169* Approved Double Insulated PV Solar Electric Power Cable

[125] UL 1741 Standard for Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources

[126] UL 9540 Standard for Energy Storage Systems and Equipment

[127] 240-108650238 Distribution Group Business Plan

2.3 Definitions

2.3.1 General

Definition	Description	Reference
air mass	Numerical value used to give an overall measure of the amount of atmosphere through which solar radiation has to pass	SANS959-1
area electric power system (Area EPS)	An EPS that serves Local EPSs	IEEE1547
battery management system	Electronic system associated with a battery, which monitors and/or manages its state, calculates secondary data, reports that data and/or controls its environment to influence the battery's safety, performance and/or service life and has the functions to cut off in case of overcharging, overcurrent, and overheating.	240-170000103
bi-directional meter	Meter that measures the active energy (Wh) flow in both directions (import and export) and either displays the balance of the imported and exported energy in a single register meter (net metering) or displays both imported and exported energy in separate registers	NRS097-2-4
black start	Start-up of an electric power system from a blackout through internal energy resources	SATS62786:2020
charge controller (regulator)	Battery charge and discharge regulator that prevents overcharging and over-discharging of a battery in a photovoltaic system by reducing the photovoltaic current, or by disconnecting the load	SANS959-1
cycle of battery	Sequence of a discharge followed by a charge, or a charge followed by a discharge under specified conditions	SANS959-1
depth of discharge (DoD	Percentage of rated capacity discharged from a battery	SATS62786:2020
distributed energy resource (DER)	Generators, including loads having a generating mode (such as electrical energy storage systems) connected to the low or medium voltage distribution network, with their auxiliaries, protection, and connection equipment	SATS62786:2020
distributed energy resource (DER) unit	An individual DER device inside a group of DERS that collectively form a system	IEEE1547
distributed energy resource managing entity (DER Managing Entity)	An entity that monitors and manages the DER through the local DER communication interface. The DER managing entity could be for example a utility, an aggregator, a building energy management system, or other	IEEE1547
distributed energy resource operator (DER operator)	The entity responsible for operating and maintaining the distributed energy resource.	IEEE1547

Definition	Description	Reference
HTML5	HTML5 is a new version of HTML with new functionalities with markup language with Internet technologies. Language in HTML does not have support for video and audio. HTML5 supports both video and audio.	
hybrid power plants	Multi-sources system with at least two kinds of energy generation technology	IEC/TS 62257-9-7:2019
import kWh	Active energy imported by the customer (received energy)	NRS097-2-4
inverter	Device that changes d.c. input into a.c. output	SANS959-1
island	A condition in which a portion of an Area EPS is energized solely by one or more Local EPSs through the associated PCCs while that portion of the Area EPS is electrically separated from the rest of the Area EPS on all phases to which the DER is connected. When an island exists, the DER energizing the island may be said to be “islanding”	IEEE1547
planned islanding	The ability decides when to run in island mode.	
unplanned islanding	The ability of the SSEG to react automatically when it detects a problem with the grid	
seamless islanding	The ability for a SSEG to form a planned or unplanned island without any interruption to loads.	
dynamic islanding	The ability of the system to adapt to unplanned events, such as a loss of generation or a fault, once the has formed	
local DER communication interface	A local interface capable of communicating to support the information exchange requirements specified in this standard for all applicable functions that are supported	IEEE1547
local electric power system (Local EPS)	An EPS contained entirely within a single premises or group of premises	IEEE1547
point of common coupling (PCC)	The point of connection between the Area EPS and the Local EPS	IEEE1547
point of connection - grid-tied (POC)	Physical connection point on the distribution network where a generating plant is connected	SATS62786:2020
point of DER connection (PoC)	The point where a DER unit is electrically connected in a Local EPS and meets the requirements of this standard exclusive of any load present in the respective part of the Local EPS	IEEE1547
renewable energy (REN)	Energy from a source that is not depleted when used	IEC/TS 62257-9-7:2019
small-scale embedded generator (SSEG)	Embedded generator rated at up to 1 MVA which includes the energy conversion device (devices), the static power converter (converters), if applicable, and the control and protection gear within a customer’s network that operates in synchronism with low-voltage networks. For avoidance of any doubt, the point of generator connection has to be at	NRS097-2-4

Definition	Description	Reference
	low voltage even if the point of utility supply is not at low voltage.	
stand by generators	An installation that incorporates alternative supplies intended to supply, either continuously or occasionally, all or part of the installation with the following supply arrangements: a) supply to an installation or part of an installation which is not connected to the main supply of a supplier. b) supply to an installation or part of an installation as an alternative to the main supply of a supplier; and c) appropriate combinations of the above.	NRS097-2-4
standard test conditions (STC)	Conditions where the irradiance is 1 000 W/m2, the temperature of the photovoltaic cell is 25 °C and the air mass is 1,5 (SEE air mass)	SANS959-1
curtailment of generators	A control system required that will measure the import of electricity from the utility and when it reaches a set point of EG capacity, the control system will start to curtail the inverters down to ensure that a minimum amount of power is being drawn into the point of supply.	NRS097-2-4

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
AFLR	A- (operator safety), Front, Lateral, Rear
AC	Alternating Current
AQL	Acceptance Quality Level
BESS	Battery Energy Storage System
BMS	Building Management System
BNEF	Bloomberg New Energy Finance
BTU	Battery Tripping Unit
C&I	Control And Instrumentation
CMMS	Computerised Maintenance Management System
CMS	Control And Monitoring System
CNC	Customer Network Centre
CoC	Certificate of Compliance
CPU	Central Processing Unit
c-Si	Crystalline Silicon
DB	Distribution Board
DC	Direct Current
DCE	Data Communication Equipment
DCS	Distributed Control Systems
DIN	Deutsches Institut für Normung

Abbreviation	Description
DMZ	Demilitarised Zones
DNI	Direct Normal Irradiance
DVD	Digital Versatile Disc
Dx	Eskom Distribution
ECSA	Engineering Council of South Africa
EMS	Energy Management System
EPC	Engineering, procurement, and construction
EPS	Electric Power System
ESS	Energy Storage System
FAT	Final Acceptance Test
FDS	Fire Detection System
FMECA	Failure Mode Effects and Criticality Analysis
GC	Gauteng Cluster
GHI	Global Horizontal Irradiation
GPS	Global Positioning System
GSM	Global System for Mobile Communication
HVAC	Heating Ventilation and Air conditioning
HMI	Huma Machine Interface
HTML	Hypertext Markup Language
IAT	Intermediate Acceptance Test
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
I_{mpp}	Maximum Power Point Current
IP	Ingress Protection
IP	Internet Protocol
I_{sc}	Short Circuit Current
KKS	Kraftwerk Kennzeichnen System
LCD	Liquid Crystal Display
LFP	Lithium-iron-phosphate
LOTO	Lock Out Tag Out
LPU	Large Power User
LV	Low Voltage (0 < LV < 1000V)
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MES	Maintenance Engineering Strategy/Standard
MIS	Maintenance Implementation Standard
Modem	Modulator-Demodulator
MSDS	Material Safety Datasheets
MWP	Megawatt Park
MPP	Maximum Power Point
Ni-Cad	Nickel Cadmium
NIE	Network Integration Equipment
NCOU	Northern Cape Operating Unit
NMD	Notified Maximum Demand

Abbreviation	Description
NTP	Network Time Protocol
O&M	Operating And Maintenance
OEM	Original Equipment Manufacturer
OHS	Occupational Health and Safety
OLE	Object Linking and Embedding
OPC	OLE for Process Control
OPC-DA	Object Linking and Embedding (OLE) For Process Control via Data Access
OT	Operational Technology
PAT	Provisional Acceptance Test
PCC	Point of Common Coupling
PCS	Power Conversion System
PDS	Plant Data System
PLC	Programmable Logic Controllers
PM	Project Manager
P_{mpp}	Maximum Power Point Power
POA	Plane Of Array
POC	Point of Connection
PR	Performance Ratio
PV	Photovoltaic
RAID	Redundant Array of Independent Disks
RAM	Reliability, Availability and Maintainability
RMU	Ring Main Unit
RPPs	Renewable Power Plants
RTU	Remote Terminal Unit
SABS	South African Bureau of Standards
SAT	Site Acceptance Test
SCOT	Steering Committee of Technology
SIT	Site Integration Test
SHEQ	Safety Health Environmental Quality
SLD	Single Line Diagram
SANS	South African National Standard
SNMP	Simple Network Management Protocol
SPR	Self-Powered Protection Relay
STC	Standard Test Condition
TF	Thin-Film
TMY	Typical Meteorological Year
UPS	Uninterrupted Power Supply
USB	Universal Serial Bus
V_{mpp}	Maximum Power Point Voltage
V_{oc}	Open Circuit Voltage

2.5 Roles and responsibilities

The development of this functional specification resides with the GC Network Engineering and Design Department (NED). This specification will form part of an EPC open enquiry for the procurement of such solutions as described by this specification. The evaluation team appointed to do the technical evaluation of any enquiry submissions will be responsible to ensure tender submissions comply with this specification. During the execution phase, the appointed project manager (PM) will be responsible to ensure that the constructed and delivered product complies with this specification, or the agreed and approved deviations.

During the Operating and Maintenance (O&M) phase, the relevant Cluster O&M Managers will be responsible to manage the contractual O&M activities.

The contractor in conjunction with the OEMs, will develop and provide the required Maintenance Engineering Strategy/ies (MES), MIS (Maintenance Implementation standard) and related documentation (maintenance base artefacts (manuals, etc.) and spares management and spares requirements) for all applicable asset classes forming part of the solution. Eskom will provide the required templates and guidance in this regard. At the commencement of the Operating and Maintenance (O&M) phase, the relevant OU / Cluster O&M Managers will be responsible to populate all the required plant data into the CMMS (Maximo).

The contractor to provide Eskom with documentation on sustainability with a commitment to environmentally friendly materials, recycling options for PV cell, inverters, and batteries, i.e., Information about proper disposal or recycling of all system components.

The contractor is also responsible for Eskom capacity building (training and training material).

The contractor shall provide full maintenance plan of the complete installation for a period of five years from date of commissioning.

Preferably the contractor must be based in Gauteng province to provide acceptable turnaround times.

The maintenance plan must be compiled providing detailed description as per the following.

- Predetermine maintenance.
- Corrective maintenance
- Preventative maintenance
- Condition-based maintenance.
- Predictive maintenance
- Reactive maintenance

2.6 Process for monitoring

Maintenance processes and requirements will be integrated into existing work management systems and these activities will be managed accordingly. E.g., for monitoring purposes during the initial or extended O&M contract periods, plant data to be populated into the Dx CMMS (Maximo) and Preventative Maintenance work orders as required by the relevant MIS, created by Dx for execution by the contractor.

The contractor is to provide feedback to Gauteng Cluster on all breakdown related information and the cluster will populate this information into Maximo on an ongoing basis.

2.7 Related/supporting documents

Not applicable

3. General requirements

3.1 Contractor's Scope of Work

1. The Contractor is responsible for consumption load recordings, design, engineering, manufacture, training, procurement and supply of all materials and labour, delivery to site, offloading, construction, erection, installation, off-site testing, on-site testing, commissioning, performance testing, provision of samples, preparation of all detail design drawings, as-built record drawings (As per Eskom requirements), maintenance manuals and instructions for the works, in accordance with the general requirements and performance requirements as detailed in this document. All works to be signed off by an ECSA accredited professional engineer
2. The contractor shall provide Eskom with all the required asset governance documents, including, but not limited to:
    a. Concept design (Including the calculation of the optimum size of the installation and load recordings)
    b. Design philosophy
    c. Detail design, and design training.
    d. Test certificates
    e. Bill of quantities
    f. Bill of materials
    g. Design and as-built drawings
    h. Commissioning documentation
    i. Maintenance (all types) manuals, fault finding manuals, maintenance training
    j. QEM documents
    k. Environmental impact studies
    l. SHEQ documentation
    m. Checklists
3. The contractor shall apply and obtain Eskom's Grid access approval in Eskom supply areas, or approval from the local municipality in municipal supply areas. Contractor shall obtain NERSA approval as per NERSA guidelines.
4. The contractor shall also obtain design approval from both the Gauteng Cluster and Eskom National design review governance committees (DRT approval).
5. The scope of work also includes the Operating and Maintenance (O&M) activities during first two (2) years of operation, with the option to extend this period, and then to hand over the asset to Eskom after the initial or extended periods.
6. The contractor shall provide a list of parts that must be kept as spares for the Maintenance and repair tasks contemplated above.
7. The scope of work also includes training of relevant cluster staff in the Operating and Maintenance of the system since commencement of the O&M contract period, and to facilitate hand over to the Gauteng Cluster at the end of the initial 2-year period.
8. The Contractor Provides the Works as per this document as well as a complete Quality Management plan as per [2], 240-105658000 Supplier Quality Management Specification.

9. The Contractor shall apply sound, recognised and current engineering practice in all designs, drawings, manuals, etc., and where these may deviate from the requirements in this document; such deviations shall be suitably motivated and substantiated by the Contractor.
10. The contractor shall provide a complete list of specifications that will apply to the system or any of its sub-components. This document contains a list of current Eskom, national and international standards that apply to the design, procurement, construction, commissioning maintenance and operating of a Solar PV and BES system. The contractor may deviate or apply different comparable standards which should be clearly indicated and motivated in the submission of tendering documents.
11. The contractor shall inspect the selected site and buildings to determine all statutory requirements and site-specific detail for such a system to ensure compliance to statutory requirements.
12. The contractor shall identify all maintainable items and spares for the system. Where an existing Eskom equipment standard applies, the contractor shall ensure that this equipment is installed, and spares be kept.
13. The contractor shall provide checklists templates to perform verification of the design, installation, and commissioning of the SSEG plant in accordance with all relevant standards and statutory requirements.
14. The contractor shall complete checklists to verify that the SSEG installation was designed, installed, and commissioned in accordance with all relevant standards and statutory requirements.
15. Training:

    1. The Contractor is responsible for the training of Eskom staff during the design, construction, operation, and maintenance of the PV Plant.
    2. Level of training required would be for Support Technicians (Task grade - T11/T12), System Engineers (Task grade - P16/T13), Operating Technician (Task grade – T11/T12), Principal Technical Officials (Task grade - T9)
    3. Training is an essential requirement from the Employer. Classroom and on-job commissioning, operation and maintenance training must form part of the overall Contract. The Contractor needs to identify the required training to operate and maintain the plant. The purpose of this training is to gain experience and exposure to the day-to-day operations and maintenance activities.
    4. All training material to be submitted to Gauteng Cluster Dx shall be in printed and digital format. This includes training material for Operators, Engineers, and Technicians. The training material provided for Engineers are required to be detailed to the level of a System Engineer. Engineers are required to be able to fully configure any system of the PV installation, including the Control and Monitoring System (CMS).
    5. The Contractor provides training in the following manner:
        a. Training on Design, Construction and Commissioning: Introduction to Project design, construction and commissioning on the project and equipment is provided by the Contractor prior to Substantial Completion of the PV Plant, such that those Employer representatives who will be at the site during normal working hours are enabled to safely shut down and/or ramp-up the plant, should that be required. This training is classroom based. The classroom training sessions are intended to provide concentrated instruction in the design, capability, operation, inspection, and control of the equipment and systems within the project. (All calculations must be provided.) Access to design software must be provided for a period of two years after completion of installation.

b. Training on Operation and Maintenance: Formal classroom and on-site training of the operations and maintenance of the plant is essential to ensure the Trainees have a sound understanding of the plant functionality and O&M requirements.

c. Training must be provided for a period of 12 months on an ad-hoc basis. This training period must be divided in a pre and post commissioning period. The training will be for a minimum of ten Eskom employees.

6. All classroom training sessions are videotaped by the Employer at its expense for future use as an orientation/teaching aid during the commercial operating period.

3.2 Registration and legal requirements

1. Contractor must be SAPVIA (South African Photovoltaic Industry Association) registered.
2. Contractor must be ECB (Electrical Conformance Board) registered.
3. Contractor must be registered with the department of labour as a registered person and have completed the SANS 10142-1 examination.
4. Contractor must be authorized to issue Certificate of Compliance for Three and single-phase electrical installations.
5. Contractor must have written accreditation from all OEM’s or accredited OEM suppliers including but not limited to, for the PV panels, inverters, and batteries to install and maintain their respective products.
6. Contractor must have a track record of at least five years’ experience in design, supply and installing of small-scale embedded generation systems.

4. Technical requirements

4.1 System description

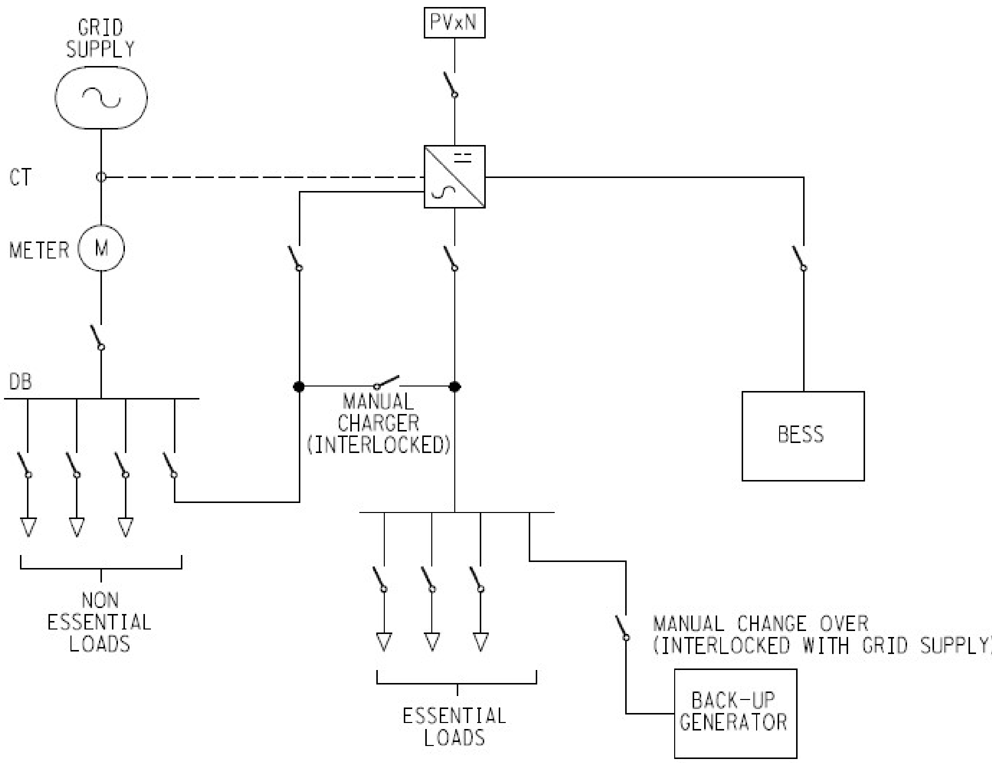

Figure 1: Block Diagram

4.2 Plant Description

This functional specification includes the following components:

1. Solar PV panels mounted on existing or new structures.
2. Battery energy storage system
3. Inverters
4. System control and communication equipment
5. Building energy management services
6. An on-site HMI
7. System site, civil earthworks (including drainage and surface preparation, where required), foundations and steelwork.
8. Air conditioning and/or related temperature and moisture management devises.

9. Fire detection and suppression system to be integrated with on-site system if applicable.
10. LV services including metering and load management.
11. Suitable and adequate earthing.
12. Suitable lighting for all operating, maintenance, and inspection activities.
13. Provision for lightning protection.
14. Safety signs and plant labelling

4.3 Capacity

4.3.1 Energy Capacity Determination

The following determination are made for this application

An integrated system (Grid, Generator (where applicable), Solar PV, BES, and EM) with enough storage to allow the building to operate directly from the PV during the usable daylight hours and from stored energy during the rest of the time. The system must be designed to provide at least eight hours of standby to all essential loads.

Temporary power consumption recorders must be installed to measure energy consumption for at least 2 weeks, to determine the optimum size of the embedded generation plant.

4.3.2 Load Management and Building Services Management

Contractor shall supply a method statement/proposal to utilise a building energy management system to prioritize loads based on available energy from PV and BESS, integrated with existing grid connection and on-site diesel /petrol /LP G generator (where applicable).

4.4 System Performance

The system shall conform to the following:

1. Performance ratio > 75%
2. Plant availability > 98%
3. The following equation is used to evaluate Performance Ratio of the plant during Performance Ratio Test for IATs and FATs (for year *n* being years 1, 2, 3, 4, or 5).

$$[PR_{measured}]_{year1} = \frac{\left[E_{prod}\right]_{year\ n}}{[E_{PV}]_{year\ n}}$$

Where:

$[PR_{measured}]_{year\ n}$ = Year *n* annual average measured PR when the plant was available during year *n* operational period, expressed in %

$\left[E_{prod}\right]_{year\ n}$ = Sum of energy measured at energy meters installed at point of connection during complete year *n* operational period, expressed in kWh

$[E_{PV}]_{year\ n}$ = Theoretical energy that could have been produced by PV modules during complete year *n* operational period, expressed in kWh

$$[E_{PV}]_{year\ n} = P_{Nom} \times \frac{[Irr_{POA-measured}]_{year\ n}}{[Irr_{STC}]}$$

Where:

$P_{Nom} =$	Nominal Peak Power of the PV Modules, sum of name plate power of modules installed in the plant, expressed in kWp
$[Irr_{POA-measured}]_{year\ n} =$	Annual average solar irradiation measured on Plane of Array during the complete year *n* period when the plant was available, expressed in kWh/m^2
$[Irr_{STC}] =$	Solar irradiation at Standard Test Conditions (STC) condition, 1 kW/m^2 (constant)

4. The Plant Availability $[AV]$ is defined as average of individual inverter availability, as shown in the equations below:

$$[AV] = \frac{\sum_{i=1}^{i=n} [AV]_i}{n}$$

Where, “i” is the number of each individual inverter and “n” is the total number of inverters in the Plant. The individual technical availability of the inverter “i” is calculated by using the equation shown below:

$$[AV]_i = \frac{T_{op}}{T_{tot} - T_{grid} - T_p - T_{fm}} \times 100 \quad \%$$

Were,

T_{op}	Total time during the measurement period where the inverter was producing energy and energy was supplied to the grid, expressed in 15 minutes interval
T_{tot}	Total time during the measurement period where the irradiation on module plane was higher than 100 W/m2, expressed in 15 minutes interval
T_{grid}	Time period during which the grid was not available (although the inverter is available), expressed in 15 minutes interval. The Contractor shall provide a written proof from the grid operator including hours during which there was a failure from grid and the Plant could not feed energy to the grid.
T_p	Time period that the inverter was not in operation (the inverter is not available) because of stoppages ordered by the Employer/third parties (insurance or authority) requirement, expressed in 15 minutes interval
T_{fm}	Time period that the Plant did not operate because of Force Majeure events, expressed in 15 minutes interval

All technical parameters mentioned in equations above are calculated for the period during which the solar irradiation on module plane is higher than the threshold level (i.e., 100 W/m2).

The contractor will provide quarterly (every four months) performance reports clearly indicating plant performance and system availability.

4.5 Safety consideration

4.5.1 General

a) A detailed Failure Mode, Effects and Criticality Analysis (FMECA) covering the entire life cycle of the plant shall be conducted, identifying all electrical, mechanical, thermal, chemical and explosion hazards. The outcomes of this assessment shall inform the need for special measures e.g., a fire detection and fire protection system, etc. Implemented mitigation measures shall be clearly detailed.

b) The SSEG shall be designed with personnel safety as the top priority.

c) In addition to electrical and physical safety requirements embodied in other portions of this standard, the design of the SSEG shall encompass due consideration for the following safety items:

   1) The use of visible disconnection points for wiring or cabling that will be handled in the course of installation and/or maintenance

   2) Self-protection functionality throughout

   3) Ground fault and loss of current monitoring

   4) Material Safety Datasheets (MSDS) shall be provided and available on-site, in an easily accessible location, for all potentially hazardous materials implemented in the ESS.

   5) All other implemented safety measures which are deemed important, but not explicitly mentioned in this section, shall be specified separately.

4.5.2 Self-protection

The system shall have the following self-protection features in place that will autonomously place the system in a safe state without any external user intervention:

a) Self-protection of the subsystem(s) in a situation where a user commands the system to do something it was not intended to do.

b) Self-protection of the subsystem(s) in a situation where an internal fault occurs (including faults of other subsystems).

4.5.3 Fire System

a) A Fire Detection System is required as a minimum. The Fire Detection System (FDS) and installation shall comply with SANS 10139 [85] as well as SANS 50054 [106] (all parts) or equivalent recognised standard.

4.5.4 Service areas

a) Service areas where humans need to work shall comply with the relevant OHS Act [78] requirements related to electrical safety.

b) More than one exit from service areas which contain high voltage and/or significantly flammable materials shall be provided.

c) All man doors and platforms shall have adequate safety features.

4.5.5 Visual and Audible emergency facilities

a) Safety signs, warning of high voltage and/or chemical hazards within the facility perimeter, 1st aid instructions and emergency shutdown instructions shall be prominently displayed.

b) Components mounted inside enclosures shall be clearly identified with suitable permanent designations that also shall serve to identify the items on drawings provided.

c) Emergency sirens, auditory and/or visual indicators shall be located on interior of enclosures inside the service areas to warn technicians inside those areas of dangerous conditions.

d) Emergency sirens, auditory and/or visual indicators shall be located outside the service areas to warn technicians outside those areas of dangerous conditions.

4.5.6 Isolation points

a) Power connections between major system components (such as between the ESS and PCS) are separable by disconnect switch which can be locked in the open position - Lockable Disconnects (LOTO).

b) Visible open point/s shall be provided between the electrical interconnection point/s and facility.

c) Prominently positioned, easily accessible Emergency STOP switches shall be provided that can render the system immediately inoperable with the aim of stopping an un-safe condition from causing continued damage.

d) Give details of lock out / tag out systems that will be used.

4.5.7 Hazards and mitigation

a) The classification of hazardous locations and proper selection of electrical equipment and mechanical equipment shall comply with Eskom Standard 240-56536505 [13] and SANS 10108 [82].

b) The different system hazards (e.g., risk of overheating, flammable and toxic gas production, thermal runaway, leakage of hazardous materials, and stranded energy in damaged batteries) shall be listed as well as mitigation factors or recommended measures to ensure safe operation of the plant and personnel safety.

4.5.8 Containment of hazardous substances

The BESS design shall include both primary and secondary containment features to contain electrolyte spills (to be emptied by contracted chemical disposal company in the event of a spill) and prevent discharge to surrounding site soils. The BESS design shall also include both primary and secondary containment features to contain discharge of potential hazardous gasses and prevent discharge into the atmosphere. Provision shall be made for an audible and visual alarm to alert staff in case of electrolyte spills or discharge of hazardous gasses.

4.5.9 Labelling and marking of equipment

a) All labelling of panels shall comply with the requirements of Eskom standard 240-62629353 [20].

b) All labelling of high voltage equipment shall comply with the requirements of Eskom standard 240-120804300 [4].

c) All markings of wiring and cables in substations shall comply with the requirements of Eskom standard 240-64636794 [23].

4.6 Protection

The system shall specifically be designed for the following type of faults:

1. Earth leakage
2. Low impedance faults
3. High impedance faults

4. Overload protection
5. Over and under voltage protection

The protection relays shall be suitable for bi-directional power flow, where applicable.

The settings shall also be able to be automatically changed based on the SSEG's operation mode – grid tied or islanded.

4.7 Automatic shutdown and restart

a) A Fault matrix shall be provided, showing the reaction of the SSEG to all possible and detectable faults within each protected area (e.g., within DC sections, within the PCS, between the PCS and intermediate transformer, within intermediate transformer primary and secondary side) and those that lead to automatic shutdown.

b) A Table showing the SSEG's response to various faults which clear externally shall be provided, also indicating those acknowledgments, or cleared faults that lead to automatic system restart. The Table shall provide various dip lengths and magnitudes and the SSEG's reaction/s.

4.8 Equipment Warranty

The Contractor provides equipment warranty according to minimum requirement set in Table 1.

In addition (and without prejudice) to the defect's liability, the Contractor releases warranty on equipment, including, but not limited to, strategic part warranty. No equipment warranty shall limit another warranty or otherwise.

The Contractor transfers the ownership of all manufacturer equipment warranties to the Employer during the Operational Acceptance of the Project.

All work carried out by the contractor shall have an unlimited warranty period of a minimum of five (5) years,

Table 1: Equipment warranty

Equipment	Minimum Warranty Period in Years
PV Module - Product Warranty against Manufacturing defects	10
PV Modules – Performance	25
Mounting structures Duration of warranty (materials)	20
Mounting structures Lifetime design warranty	25
Inverter	10
HVAC Equipment	5
Fire Protection Equipment	5
Batteries	5
Solar geysers / heat pumps / Direct PV [DC] supplied geyser element	5
Air Conditioning Units (HVAC)	5
Natural Light opening (Skylights)	5
Energy efficient boilers or direct heating systems or alternatives	5
Energy efficient air conditioning replacements or upgrades.	5

4.9 PV System

4.9.1 General

1. The Contractor is responsible for the detail design, plant interface design, manufacture, factory testing, supply, delivery, off-loading, move into position, installation, assembly, site testing and commissioning of all new equipment forming part of the PV electrical scope.
2. The contractor is responsible for reconfiguring the buildings LV reticulations systems to allow for only critical loads such as server room with HVAC, lighting, plugs, critical IT equipment, security system, are connected to the embedded generation system. The Electrical distribution board must be reconfigured that critical and non-critical loads are on separate circuits. All IT equipment must be included in the critical load design. Provision must be made for at least one electrical outlet to be used as supply for a kettle.
3. The contractor is responsible for applying the maximum energy saving technology throughout the building as first priority, before designing the PV and ESS system. The contractor may use its own discretion and possibilities include, but not limited to:
    a. Replacement of existing indoor luminaires with LED luminaries, while still maintaining OHS act lighting requirements. (Additional luminaires and/or luminaire fittings may be added to reach the required light levels, for normal and emergency conditions).
    b. Replacement of existing external luminaires with LED luminaries, while still maintaining OHS act lighting requirements, SANS, and related Eskom lighting requirements. (Additional luminaires and/or luminaire fittings may be added to reach the required light levels, for normal and emergency conditions).
    c. Creating openings and using technology to introduce additional natural light into the buildings
    d. Solar geysers / heat pumps / Direct PV [DC] supplied geyser element (including replacement of element and supporting equipment, where required) where hot water is used for showers / baths (Gas alternatives will not be accepted).
    e. Energy efficient boilers or direct heating systems or alternatives, where water is used for direct consumption (Gas alternatives will not be accepted).
    f. Energy efficient air conditioning replacements or upgrades.
    g. Installation of door sensors, that are integrated with the air conditioning or EMS system, to reduce consumption.
    h. Gas stoves or gas heating will not be accepted.
    i. Introducing designated plugs for heaters, where extensive requiring will not be required (this will not be a critical load)
    j. Signs to use energy efficiently.
4. The Contractor designs and specifies all electrical equipment/system in accordance with the current Employer’s requirements, National and International standards, specifications, and guidelines referenced in this technical specification.
5. The Contractor designs the PV Plant with due consideration to the minimisation of lifecycle costs (achieving an optimal balance between delivered kW, kWh, reliability, life cycle cost, maintainability, and overall cost effectiveness).
6. The PV electrical scope breakdown structure is summarised in Table 2.

Table 2: PV electrical scope breakdown structure

Component	Description
PV Modules	PV modules of same technology, type, model, size, batch and from the same manufacturer.
Mounting Structures and foundations	Fixed mounting structure attached to the structures. Designed in compliance from geotechnical investigations (if applicable). Compliance with Environmental and Water use license approval (if required).
Combiner boxes, Fuse boxes	Combines strings / combiner boxes / fuse boxes with adequate protection and monitoring before connection to the inverter.
Inverters	Inverter concept suited to operating temperature at site conditions, and with the application of suitable ventilation and cooling systems. Input for numerous strings (as may be required by the site), such that the optimal amount of energy generated from the PV modules can be supplied to the system.

4.9.2 PV Capacity

1. The Contractor designs the required PV capacity to sufficiently provide energy to address the system source sizing requirements. That is the as per par 4.3 in this specification.
2. The PV panels are mounted on compliant supporting structures attached to the structures with an optimal and fixed tilt angle. The PV panel dimensions, and orientation are influenced by the maximum allowable area on the supporting structure and as advised by the results of an industry acceptable solar radiation simulation study of the site and GPS coordinates. Wind loading on the structure and panels to be considered for the site(s). The compliant supporting structures shall consist of corrosion free materials and fasteners that does not require any on-site welding or similar electromechanical process. If cutting and drilling of structure materials are required during manufacturing and on-site, this shall not in any way negatively affect the corrosion resistivity of the supporting structure materials.
3. The DC capacity is the sum of nominal power of all modules (defined at STC) to be installed. The AC capacity is the sum of nominal power of all inverters (without derating) to be installed.
4. The PV array sizing does not overload and overheat its corresponding inverter(s) (as per manufacturer’s recommendation) at any time during the year.
5. The Contractor designs the string size in such a way that inverter(s) always operates within its MPP range throughout anytime of the year and throughout the project lifetime.

4.9.3 PV Modules

1. The Contractor supplies and installs the PV Modules to achieve the specified levels of performance for the required design life of 25 years under the prevailing site environmental conditions, which shall be investigated and are determined by the Contractor.
2. The Contractor shall comply with IEC 61215-1 [43] and IEC 61215-2 [48].
3. The Contractor, at minimum, shall comply with IEC 61215-1-1[43] for a crystalline silicon (c-Si) PV Module technology.
4. The Contractor, at minimum, shall comply with IEC 61215-1-2 [48], IEC 61215-1-3 [46], IEC 61215-1-4 [47] for a thin-film (TF) PV Module technology.
5. All PV modules supplied for the Plant are of the same type, model, size, batch and from a single manufacturer and installed according to the manufacturer’s specifications.

6. The module manufacturer selected shall be on BNEF (Bloomberg New Energy Finance) Tier 1 list at the time of publication of this bid OR have a track record of 5 years manufacturing experience producing 50MW/year. Tier 1 in this context refers to the Tier 1 list of Bloomberg New Energy Finance (BNEF), in the version as of the date of publishing of the tender documents. Locally assembled modules are considered Tier 1 if there is a clear trail to one of the manufacturers of the BNEF Tier 1 lists. The Contractor provides proof of the offered module under the Tier 1 List.
7. Bidder to provide a datasheet of the Tier 1 manufacturer name OR a letter from the manufacturer stating the modules relevant track record information listed above.
8. The PV module type offered shall have been deployed and in operation in the field for similar ambient temperature (≥38°C) for at least 12 months in commercial financed non-recourse projects.
9. The PV modules minimum guarantees from the manufacturer are:
    a. Guaranteed minimum power output of 97% during the first year of operation.
    b. Linear maximum degradation coefficient guarantees of 0.75 % per year from year 2 to year 25
    c. Guaranteed minimum output of 90% of the nominal power after 10 years of operation
    d. Guaranteed minimum output of 80% of the nominal power after 25 years of operation
    e. Workmanship Product guarantee against manufacturing defects for a minimum of 10 years.
10. The module rated peak power (defined at STC condition) is used to determine the peak power of the PV System. The peak power is the sum of the manufacturer's name plate data sheets for each individual module.
11. Modules shall have anti-reflective coating, The PV modules have frames sufficiently resistant to corrosive environments (Aluminium Alloy, Anodized Aluminium, etc.); these modules shall have valid IEC certifications.
12. The Contractor provides the flash test data from the manufacturer (measurement according to IEC 60904-1 [42]) for each module to be installed in the project. The sum of power in flash test data shall equal to or higher than peak power of the Plant.
13. The Contractor is responsible to decide the module arrangements to minimize the losses due to mismatching.
14. The Contractor uses a proper sorting method and only modules from the same set and batch are used in the same string.
15. All transportation, storage, handling, and installation of the modules are in accordance with the specifications from the manufacturer, so as not to void the module manufacturer's warranty.
16. The Contractor verifies the quality of PV modules according to the requirements set in the inspection, test, and commissioning section of this specification.
17. The Contractor provides PV modules complying with the minimum specific technical requirement set in the Tender Technical Schedules.

4.9.4 DC Combiner and Fuse Box

1. The combiner and fuse box are rated for exterior environmental conditions and suitable for working environment prone to corrosion with a design lifetime of minimum 25 years. These boxes shall remain corrosion free for the design lifetime and provide as a minimum IP 65 ingress protection as defined by IEC 60529 [39].
2. The combiner box must have the capability to house the devices for overcurrent protection for each individual string, string level monitoring equipment, on-load disconnector switch for array isolation and surge arrestors for over voltage protection.

3. The combiner box includes DC string protection for each string and operates at a Maximum DC Voltage of 1000V DC.
4. The DC combiner box includes as a minimum lightning and overvoltage protection. Surge protection is provided on both the DC and the AC side of the solar system.
5. The DC combiner box includes an array on-load disconnect switch to provide protection and isolation capabilities, which is:
    a. Accessible without opening the combiner box.
    b. Lockable.
    c. Double pole to isolate both the positive and negative PV array cables.
    d. Rated for DC operation.
    e. Capable of breaking under full load.
    f. Rated for the system voltage and maximum current expected; and
    g. Equipped with safety signs.
6. The combiner box includes a DC short circuit protection device for the disconnection of supply in case of fault conditions.
7. The combiner box is equipped with sun shields were exposed to direct sunlight. To prevent overheating inside the box, reduced terminal occupancy is considered. The place of installation location shall be easily accessible and offer a secure base for working on the device.
8. The cable labelling and single line diagram of connections inside the combiner box is kept on each combiner box.
9. The box has an IP of 65 [39] or higher.
10. The fuse box includes a fuse for each input from combiner box.
11. The fuse box is equipped with sun shields were exposed to direct sunlight. To prevent overheating inside the boxes, reduced terminal occupancy is considered. The place of installation location shall be easily accessible and offer a secure base for working on the device.

4.9.5 Inverters

1. The Contractor provides an inverter arrangement that gives overall optimal energy yield over the life of the Project, considering the site conditions and the proposed module layouts and configurations.
2. The inverter manufacturer complies with the following:
    a. Has been producing inverters for last five years,
    b. Has minimum annual production capacity of 50 MW,
3. Inverters selected for the Project conform to the following specifications:
    c. Inverter minimum nominal capacity (without deration)
    d. Inverter is selected with respect to local climatic and environmental condition and is equipped to operate in high temperature regions,
    e. The inverter type or series offered for the Project has been deployed and in operation on field (with ambient temperature up to ≥ 38 °C) in past 12 months,
    f. The inverter power is not derated for the temperature range between -10 °C and +45 °C,
    g. Inverters selected for the Project has a minimum of 10 years product guarantee against manufacturing defects.

4. The Contractor confirms the inverter manufacturer's warranties for the site-specific environment and installation type. The Contractor also mentions if the inverter warranties can be extended. Possible extension of warranties is preferred.
5. The Contractor provides the list of spare parts required for the operation of inverter over 25 years period, recommended by the inverter manufacturer.
6. Inverters meet the following general requirements:
   a. Due to maintenance reasons and a conservative spare part approach, inverters of the same type, model and size from the same manufacturer is deployed over the whole project.
   b. Inverters are equipped with communication capabilities as required by the Control and Monitoring System (CMS); all inverters are able to be controlled / supervised by the same software or CMS system presented in this document.
   c. Detail requirements are covered in section 4.12
7. The inverters comply with safety requirements according to IEC 62109 [60].
8. Inverters are provided with lockable DC disconnect switch and AC disconnect switch for isolation.
9. An IP protection class of at least 21 is required for indoor mounting of the inverters and at least 65 [39] is required for outdoor mounting.
10. The Contractor submits calculations for ensuring electrical compatibility between the inverters and the modules selected including, selection of appropriate inverter dimensioning factor and ensuring system voltages lie within acceptable MPPT ranges across the range of operating conditions for the site and for the long-term operation of the project.
11. All transportation, storage, handling, and installation of the inverters are in accordance with the specifications from the manufacturer, as to not void the inverter manufacturer's warranty.
12. The quality of inverters is verified according to the requirements set in sections 4.10.9 3 . [There is par 4.10.9.3?]

4.9.6 PV Electrical System Codes and Standards

All equipment and services supplied comply with the codes and standards listed below.

1. General:
   - SANS 10142-1 [87] – The wiring of Premises – Part 1: Low voltage installation.
   - 240-61268576 [18]: Standard for the Interconnection of Embedded Generation
   - NRS 048 [75] – Electricity Supply - Quality of Supply
   - Occupational Health and Safety Act 85 of 1993 [78]
2. PV Modules
   - IEC 61215-1 [43]- Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test Requirements.
   - IEC 61215-1-1 [44] - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules.
   - IEC 61215-1-2 [45] - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-2: Special requirements for testing of thin-film cadmium telluride (CDTE) based Photovoltaic (PV) modules.
   - IEC 61215-1-3 [46] - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-3: Special requirements for testing of thin-film amorphous silicon based photovoltaic (PV) Modules

- IEC 61215-1-4 [47] - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-4: Special requirements for testing of thin-film Cu (In, GA) (S, Se)2 based photovoltaic (PV) modules
- IEC 61215-2 [48] - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 2: Test procedures
- IEC 61730-1 [55] - Photovoltaic (PV) module safety qualification - Part 1: Requirements for Construction
- IEC 61730-2 [55] - Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
- IEC 61701 [51] - Photovoltaic (PV) modules - Salt mist corrosion testing
- IEC 62716 [65] - Photovoltaic (PV) modules - Ammonia corrosion testing
- IEC 60891 [41] - Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics
- IEC 60904-1 [42] - Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage Characteristics
- IEC 60904-2 [42] - Photovoltaic devices - Part 2: Requirements for photovoltaic reference devices
- IEC 60904-3 [42] - Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data
- IEC 60904-7 [42] - Photovoltaic devices - Part 7: Computation of the spectral mismatch correction for Measurements of photovoltaic devices
- IEC 60904-8 [42] - Photovoltaic devices - Part 8: Measurement of spectral responsivity of a photovoltaic (PV) device
- IEC 60904-9 [42] - Photovoltaic devices - Part 9: Classification of solar simulator characteristics
- IEC 60904-10 [42] - Photovoltaic devices - Part 10: Methods of linear dependence and linearity measurements
- IEC 61829 [56] - Photovoltaic (PV) array - On-site measurement of current-voltage characteristics
- IEC 61853 [57] - Photovoltaic (PV) module performance testing and energy rating
- IEC 60068-2-78 [36] - Environmental testing - Part 2-78: Tests - Test Cab: Damp heat steady state
- IEC 6134 [49] - UV test for photovoltaic (PV) modules
- IEC 62548 [64] - Photovoltaic (PV) arrays - Design requirements

3. Inverters

- IEC 62093 [59] - Power conversion equipment for photovoltaic systems – Design qualification testing
- IEC 62109-1 [60] - Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
- IEC 62109-2 [60] - Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
- IEC 62109-3 [60] - Safety of power converters for use in photovoltaic power systems - Part 3: Particular requirements for electronic devices in combination with photovoltaic elements
- IEC 62116 [61] - Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
- SANS 60730 [107]-1: Automatic electrical controls - Part 1: General requirements

- IEC 61683 [50]: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
- SANS 61000-6-2, 3 and 4 [109]: Electromagnetic compatibility (EMC)
- IEC 61727 [54] - Photovoltaic (PV) systems - Characteristics of the utility interface
- Grid connection code for Renewable Power Plants (RPPs) connected to the electricity Transmission system (TS) or the Distribution system (DS) in South Africa Version 3 [35]
- IEC 60364-7-712 [38] - Electrical Installations of Buildings: Requirements for Special Installations or Locations – Solar Photovoltaic power supply systems

4. Electrical Cabling
    - Requirements for cables for use in photovoltaic systems 2Pfg1169" by TÜV [124]
    - SANS 1507 Part 1 [102] : General - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
    - SANS 1507 Part 2 [103]: Wiring Cables - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
    - SANS 1507 Part 3 [104]: PVC Distribution cables - Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
    - SANS 10198 Parts 1-14 [89] The selection, handling, and installation of electric power cables of rating not exceeding 33 kV Part 1 to 14
    - SANS 1411-2 [100]: Materials of insulated electric cables and flexible cords Part 2: Polyvinyl chloride (PVC).
    - SANS 1411-4: Materials of insulated electric cables and flexible cords Part 4: Cross-linked polyethylene (XLPE)
    - SANS 1213 [[98] Mechanical Cable Glands
5. Lighting and Small Power
    - SANS 164 [105] : Plug and socket-outlet systems for household and similar purposes for use in South Africa
    - SANS 890 [114] : Ballasts for fluorescent lamps
    - SANS 1041 [90] : Tubular fluorescent lamps for general service
    - SANS 1088 [91] : Luminaire entries and spigots
    - SANS 10142-1 [87] : The wiring of premises Part 1: Low-voltage installations
    - SANS 10114-1 [83] : Interior lighting Part 1: Artificial lighting of interiors
    - SANS 10114-2 [84] : Interior lighting Part 2: Emergency lighting
    - SANS 1266 [99] : Ballasts for discharge lamps (excluding tubular fluorescent lamps)
6. Earthing, Lightning, and Surge Protection
    - SANS 62305-1 to 4 [113] - Protection against lightning - Parts 1 to 4
    - SANS 61643-12 [112]- Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power systems
    - SANS 10142-1 The wiring of Premises – Part 1: Low-voltage installations
7. Performance Monitoring
    - PD IEC TS 61724-2 [79] : Photovoltaic system performance. Part 2: Capacity evaluation method

- PD IEC/TS 61724-3 [80] : Photovoltaic system performance. Energy evaluation method
- IEC 61683 [50] : Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
- IEC 60364-6 [37] : Low Voltage Electrical Installations-Verification
- IEC 62446-1 [62] : Photovoltaic (PV) Systems-Requirements for testing, documentation, and maintenance-Part 1: Grid connected systems-Documentation, Commissioning tests and inspection
- IEC 62446-2 [63] : Photovoltaic (PV) Systems-Requirements for testing, documentation, and maintenance-Part 2: Grid connected systems-Maintenance of PV systems.
- ISO 9845-1 [70] : solar energy - Reference solar spectral irradiance at the ground at different receiving conditions, Part 1: Direct normal and hemispherical solar irradiance for air mass 1.5.
- ISO 9847 [71] , solar energy - Calibration of field pyranometers by comparison to a reference pyranometer. / BS 7621: Method for calibrating field pyranometers by comparison to a reference pyranometer
- ISO/TR 9901 [72] : Solar energy - Field pyranometers – Recommended practice for use.
- IEC 61725 [53] : Analytical expression for daily solar profiles

4.10 Energy Yield Estimations

1. As part of the bid submission, the Contractor shall provide the P50 and P90 TMY datasets used as input in their simulation model, and the energy yield estimation report describing the methodology and TMY used to estimate the Solar PV system energy yield over the design life, while accounting for the requirements under the section Customer Connections and the guaranteed degradation rates, forming the basis of the guaranteed performance.
2. The design data specified in this document and those dimensions shown on the tender drawings are intended for tendering purposes only. The Contractor is required to take the actual measurements onsite before proceeding with design and manufacture of the complete works as dimension accuracy remains the responsibility of the Contractor.
3. The Contractor defines the PV Plant performance and provides the guaranteed performance ratio and plant availability calculation along with detail calculation and losses assumptions. The Contractor uses industry standard methods and simulations for carrying out yield and performance ratio calculations and demonstrates the basis of the calculations.

4.11 Power Conversion Systems (PCS)

4.11.1 General

a) The power conversion systems shall enable the system to have the capability to seamlessly connect or disconnect from the main grid and standby generator (where applicable) as physical and/or economic conditions dictate. It shall be possible to operate in both grid-connected mode (synchronous with the grid), or in island mode (functioning autonomously and disconnected from the main electric grid). Grid-tied operation is dependent on approval from the relevant supply authority.

b) Islanding is a condition in which distributed generators (DG) continue to provide power in a location even without the continued presence of electrical grid power – in this operating mode, the SSEG will be safely isolated from the main grid.

c) The PCS connected to the energy storage system shall be a bi-directional inverter that can provide real and reactive AC power simultaneously with full four quadrant operation.

d) The PCS shall comply with UL 1741 [125] or equivalent industry accepted technical standards.

e) The PCS shall also comply with NRS 097-2-1:2017 [77] , Grid Interconnection of Embedded Generation; Part 2: Small-scale Embedded Generation; Section 1: Utility Interface.

f) All LV switchgear and control gear shall comply with the requirements of SANS 61439 [110] or equivalent technical standards.

g) The ability of the assembly of LV switchgear to limit the risk of personal injury, damage of assemblies and its suitability for further service as a result of an internal arcing fault shall be in accordance with SANS 61641 [111]or equivalent technical standards.

4.11.2 System Operation

a) The PCS shall be modular and scalable. Hot-plug ability is preferred, but not mandatory. The modules may be rack-mounted facilitating easy and safe handling.

b) Multiple PCS shall be capable of operating in parallel, assuming isolation is provided on the AC bus, while maintaining adequate load sharing with failure proof controls.

c) The PCS shall operate on the always-on principle where power output is derated based on operating temperature limitations.

4.11.3 Monitoring and Controls

a) The PCS shall be capable to adjust the output voltage & frequency to suit the grid condition. The PCS must be able to synchronize with the grid frequency and provide a stable output – appearing to the grid to be a synchronous generator.

b) Suitably rated contactors or equivalent automated disconnecting devices shall be provided for the connection of the inverter input – and output terminals to the battery DC bus and to the three phase AC isolation power transformer, respectively.

c) A disconnect switch, with padlock capability, shall be provided for isolation of the inverter from the DC battery string.

d) A lockable AC disconnect shall be provided for the connection of the PCS to the isolation power transformer.

e) An option for disconnectors with visible contacts may be provided upon customer / Employer request.

f) Suitably rated overcurrent protection devices shall be provided on both the AC and DC buses.

g) Communication ports (USB Type A, C and/or Micro) shall be provided for interaction with the BMS and EMS, where applicable.

h) Local connection via a computer shall be possible for maintenance purposes.

i) All fault conditions and events shall be date-and-time stamped and shall be retained in memory in the event of power loss for later recall.

j) The operator interface shall consist of an emergency stop button, a means to enable and disable the system and status indicators.

k) The operator interface shall be capable of controlling the PCS, displaying system status, and annunciating any fault conditions.

l) Where the PCS is not part of the battery system container / cabinet, it shall be installed in an outdoor IP 65 [39] rated cabinet.

m) The following PCS parameters shall be monitored and reported on in real time for each lowest maintainable unit / module:

1) DC current
2) DC bus voltage
3) DC power
4) AC phase currents

5) AC phase voltages
6) Power factor
7) AC real power
8) AC reactive power
9) AC apparent power
10) Available energy in hours or expressed as a percentage of battery capacity

n) The *Tenderer* / Contractor shall specify a list of all critical PCS parameters, detailed historical data logging for performance analysis and troubleshooting, that can be monitored via the EMS.

4.11.4 Balance of System

a) The *Tenderer* / Contractor shall list all equipment / sub-systems that make up the balance of plant and also indicate how it interfaces with the EMS.

b) All LV switchgear and control gear shall comply with the requirements of SANS 61439 [110] or equivalent technical standards.

c) The ability of the assembly to limit the risk of personal injury, damage of assemblies and its suitability for further service as a result of an internal arcing fault shall be in accordance with SANS 61641 [111] or equivalent technical standards.

4.12 Energy storage system (ESS)

a) The energy storage system shall charge when there is excess energy in the system and discharge as dictated by the Energy Management System.

b) Only commercially available battery (electrochemical) energy storage systems with a track record shall be evaluated as part of this enquiry. Compliance to 240-170000103 Lithium iron phosphate batteries standard [7] is mandatory. Batteries shall comply to electrical performance requirements as per 240-170000103 Lithium iron phosphate batteries standard [7].

c) The energy storage system shall comply with the requirements of industry accepted test standards that verify its technical performance, robustness to normal use and mechanical -, electrical – and environmental abuse events. The tenderer shall indicate the relevant test standard applied (and associated test certificate obtained from an independent, 3rd party, accredited verification authority) as well as any other tests deemed critical for the use-case and operating environment.

d) The following minimum tests are required:

1) External short-circuit
2) Abnormal Charge / Overcharge
3) Forced Discharge / Over discharge
4) Impact
5) Drop
6) Heating
7) Internal short circuit test or thermal propagation test
8) Overcharge control of voltage
9) Overcharge control of current
10) Overheating control – i.e., Thermal protection.

e) The system shall be modular and scalable.

f) Balancing of a string/module/cell shall be done online without affecting the operation and required availability of the system.

g) Any faulty string/module/cells shall be flagged and safely isolated without affecting the operation and required availability of the system.

h) It shall be possible to introduce improved battery technologies / models in future, whether for augmentation or upgrading purposes, without negatively affecting the performance and life of the battery modules that are not been replaced. The *Tenderer* / Contractor shall state how this “future-proofing” shall be accommodated in existing designs in terms of the EMS, BMS and PCS.

4.12.1 Battery management system (BMS)

a) The *Tenderer* / Contractor shall specify if any or all the requirements under this Section are performed by other sub-systems or shared. Please note that some of the mentioned parameters may not be applicable to some BESS technologies, in which case the *Tenderer* / Contractor shall indicate this.

b) The BMS shall be designed to ensure automatic, unattended operation of the BESS.

c) The BMS shall provide the necessary monitoring and control to protect the battery cells/module/string from out of tolerance or unsafe operating conditions.

d) The BMS shall automatically control the safe charge and discharge of the individual cells/modules/strings.

e) The BMS shall automatically control balancing between cells/modules/strings (where applicable) to ensure optimised state-of-charge, state-of-health, and life expectancy.

f) The BMS shall automatically monitor cell/module/string heath and provide critical safeguards to protect the batteries from damage.

g) The BMS shall monitor and report in real time on the following parameters for each lowest maintainable unit / module:

11) State-of-Charge (SoC)
12) State-of-Energy (SoE)
13) State-of-Health (SoH)
14) Battery temperature
15) Charge current
16) Discharge current
17) DC bus voltage
18) Cell / Module / Stack voltages (Minimum and maximum)
19) Cell / Module / Stack / Electrolyte temperatures (Minimum and maximum)

h) The BMS shall monitor and report in real time on the following alarm or warning conditions for each lowest maintainable unit / module or cell:

1) Over-temperature i.e., Thermal protection.
2) Overcharge
3) Over-discharge
4) Undercharge
5) Over Voltage

4.13 Diesel / Petrol / LP Gas generators

a) The controller of the existing diesel generator shall interface with the EMS of the SSEG.

b) The contractor shall design, supply, and install a manual change -over system that are able to manually connect a back-up generator to the essential loads of the CNC in case of system interruption. The generator/ s will only be used in prolonged system outages. The generators may not form part calculation when battery sizing of the site is calculated.

4.14 Management and Control

4.14.1 General

a) The EMS shall have the capability to seamlessly connect to or disconnect from the main grid as physical and/or economic conditions dictate. It shall be possible to operate in both grid-connected mode (synchronous with the grid), or in island mode (functioning autonomously and disconnected from the main electric grid). Islanding is a condition in which distributed generators (DG) continue to provide power in a location even without the continued presence of electrical grid power – in this operating mode, SSEG will be safely isolated from the main grid. Grid-tied operation is dependent on approval from the relevant supply authority.

b) Eskom shall be fully licensed and own all EMS software including all the operational firmware, monitoring and control & maintenance software used locally on site including the HMI's and remote monitoring/control/communication software. There shall be no feature or usage time limit on the software.

c) Complete access to all portions of software code and the option to make changes to the software from Eskom's side are preferred.

d) The contractor shall ensure that Eskom has access to continuous updates of all firmware and / or software releases during and after the warranty periods without any restrictions.

e) The solar PV and ESS system shall be operated and maintained by the local Eskom CPM department. CPM shall also be responsible for any software changes and firmware updates. The contractor shall, during the M&O phase of the contract, maintain a parallel remote engineering link, to enable the contractor to perform any on-line activities. The contractor shall ensure that any system changes done at its on-line workstation are logged and captured. Eskom must have remote access to this information. The contractor shall demonstrate compliance to relevant international cyber security standards as well as 240-55410927 Cyber Security Standard for Operational Technology [12].

f) The outputs from all critical sub-systems required as inputs for optimal system operations shall terminate at the EMS as inputs and be utilised for deciding which controls shall be issued to the different sub-systems.

g) All protocols required for effective interaction between the different sub-systems shall be supported.

4.14.2 EMS functionality

a) The EMS shall actively maintain a balance between the available generation supply sources and load demand using an intelligent control system that ensures careful management of supply and demand.

b) When the generation sources (grid, solar PV and/ or generator) are constraint, the EMS shall ensure that all critical loads remain connected (as far as possible) and controllable loads are managed as dictated by the operating constraints.

a) For optimal system safety, the safety management functions, and operational management functions should be embedded at different levels of the SSEG. As a very last resort, the EMS shall ensure that sufficient power is always allocated for safe shutdown of the SSEG as well as on-demand restart of the SSEG under more suitable operational conditions. The EMS shall be designed to provide for automatic, unattended operation of the SSEG. However, the control system design also shall provide for local manual operation. The EMS shall facilitate the real time monitoring, operation, control, reliable, efficient, and safe operation, and performance optimization of the BESS system. The EMS shall be able to acquire real time data, status – and alarm information from all critical subsystems necessary for the effective and safe operation of the BESS:

   1) Switchgear
   2) Protection relays and schemes
   3) Energy and power meters
   4) UPS
   5) Power Conversion System
   6) Fire System
   7) GPS Time Synchronisation unit
   8) Battery Management System
   9) HVAC system
   10) Any other equipment deemed necessary

b) The EMS shall display the following system parameters:

   1) Grid / System Voltages
   2) Grid / System Currents
   3) Power factor
   4) Apparent Power
   5) Reactive Power
   6) Active Power
   7) System status and alarms
   8) System temperature/s
   9) Ambient temperature
   10) BESS SoC and SoH
   11) All other data necessary for operation and fault finding, including diagnostics and self-check functions as well as all required diesel /petrol or LP gas generator information.

c) It shall be possible to configure operational settings (e.g., setpoints, alarm levels, etc.) of all subsystems from the EMS. An audit trail (date, time, and user stamping) of all configuration changes shall be recorded and stored for future reference.

d) The ramp rate of charging and discharging of the ESS shall be programmable or set to a defined value by manually entering a value into the ESS HMI or remotely.

e) All modes of operation and its operational set-point functionality shall be remotely adjustable to allow change in settings and to turn on/off all controls or modes when appropriate.

f) The EMS shall log, and store critical system parameters, alarms, events, and trends required for the effective performance management of the BESS. This data shall be date and time stamped.

g) It shall be possible to configure the EMS with user friendly configuration files.

h) It shall be possible to generate, store and retrieve user configurable periodic reports. It shall be possible to generate these reports in MS Office (MS Word or MS Excel) formats.

i) The EMS of the SSEG shall be capable of operating on autonomous control.

j) The EMS shall ensure safe SSEG operation under all operating conditions, inclusive of any plant disturbances and component failures.

k) The EMS design shall incorporate redundancy to ensure the continued operation of the SSEG in the event of the failure of a main processing unit. The contractor / tenderer shall indicate in the Tender how redundancy is achieved and how will this impact on the HMI functionality of the EMS.

l) Manual (local and remote) intervention shall always be possible at any stage of operation in compliance with the following priority assignment:

   1) Protective commands shall have priority over manual command and

   2) Manual commands shall prevail over automatic commands

m) The control algorithms shall be designed to fulfil primary use cases and optimise stacked benefits.

n) The EMS shall be capable of keeping track of how the SSEG performs compared to warranty requirements and report on exceptions.

o) The EMS shall keep track of the usage profile of all SSEG plant in line with warranty requirements and note any exceptions.

p) The following shall apply to the ESS

   i) Considering the manufacturer's expected lifespan of the installed ESS technology, the time and date at which the unit was commissioned, the number of charge and discharge cycles, the depth of discharge etc. the EMS shall be able to indicate the estimated remaining lifespan of a battery cell, module, rack and/or string.

   ii) It shall also indicate based on the estimated lifespan what the maximum charge/discharge capability of each battery cell, module, rack and/or string is as a percentage (with 100% representing the designed charge/discharge capacity of the battery when new).

4.14.3 Human Machine Interface (HMI)

a) The EMS shall provide a local HMI in the control room (demarcated area in the building) which will provide a facility to locally control the system while providing a view of the plant statuses and alarm conditions at the site. Eskom's envisaged operating philosophy is to ensure that most/all local operations are performed on the station object or the bay object via the EMS HMI and not from the individual devices.

b) The HMI shall provide a graphical interface for monitoring and control of the system. The HMI shall allow the SSEG system to be drawn with the appropriate status points and alarms being indicated. It is preferred that IEC approved electrical components/symbols be used/supported on the HMI drawing tool (e.g., bi-directional converter symbol, energy storage device symbol).

c) It is preferred that the ability to access settings and configure the SSEG subsystem components is possible via the HMI.

d) The HMI system shall be rated for 24/7 continuous use.

e) All interactions (viewing and control) of the HMI shall be done via a display (non-touch/touch).

f) The HMI hardware and display shall be suitably rated for operation in the harsh environments in which it will be installed in.

g) The life expectancy of the HMI hardware shall be greater than 5 years. The Tenderer / Contractor shall provide the life expectancy of the HMI offered as part of their Tender submission

h) Fanless, redundant solid-state drives shall be provided.

i) The HMI shall be remotely accessible.

j) It is recommended that the HMI support a web-based view that can be served to external web-browsers. If supported, such functionality shall use HTML5.

k) A safety requirement of this system is that the HMI from which the Eskom/third party operator can monitor and control the SSEG system (where applicable) shall be located in an environment that is free of equipment that can cause any harm to the operator during their operating processes (e.g., switches, inverters, battery banks). A suitably demarcated area shall be provided.

l) l) It is recommended that all incorrect operations shall be indicated to the operator by suitable text messages on the HMI screen.

m) m) All control functions relating to output data (i.e., control of primary plant) shall include a confirmation window to ensure accidental operations are avoided.

n) n) All control actions initiated via the local HMI shall be subject appropriately interlocked to always ensure safety to person and plant.

o) a) The HMI shall support the viewing of this Sequence of Event data.

4.14.4 GPS Time Synchronisation Device

The SSEG shall include a Global Positioning System (GPS) Time Synchronisation unit (master clock) suitable for use in substation/industrial environments for the purposes of time synchronising all the devices and events within the small-scale embedded generator.

4.14.5 Power Supplies Requirements

a) There shall be no equipment malfunction, damage, or spurious event, under any of the following conditions:

   1) As a result of the loss or restoration of supply.

   2) As a result of an under-voltage (-20%) or over-voltage (20%) condition of the nominal voltage supply.

   3) If either AC or DC supplies to the unit are switched off and on repeatedly at a random rate.

   4) Short interruptions on any of the power supply voltages for not longer than 20ms occurring in a random sequence for a period of no longer than 20s.

b) All critical sub-systems shall be powered from an UPS to remain operational in the event of an auxiliary power supply failure. This is necessary to ensure the safe shutdown of the SSEG.

c) The BMS shall reserve as suitable amount of battery capacity to ensure the safe shutdown of the SSEG plant in case of auxiliary power supply failure and /or UPS failure.

d) The UPS shall comply with the requirements of IEC 62040-1 [58] and IEC 62040-1-2 [58].

e) The power supplies shall have the necessary over-temperature protection, current overload cut-outs and over-voltage limiting, with automatic reset on removal of the fault.

f) A Light-emitting Diode (LED) indication, with a check facility, shall be provided to indicate a supply healthy condition for all internal supply voltages. It is preferred that a contact and or port be available to communicate power supply health remotely.

g) In addition, the design shall provide a floating power supply regardless of any earthing which may exist on the DC supply rails.

h) If the EMS Gateway is supplied from a DC source, the noise measured across the power supply terminals of the equipment under test shall not be greater than 2 mV peak-to-peak or -58dBV (0dBV = 0,775V) measured psophometrically.

i) The power supply unit shall provide galvanic isolation between the primary supplies and the electronic circuitry.

j) The output terminals for powering the external DCE/converters and other equipment shall be capable of accepting 2,5mm^2 cable.

4.15 IT and Communication Requirements

4.15.1 Communication Gateway Requirements

a) The EMS's control system shall interface with the Approved Gateway for remote access through its IED/local interface ports. The required cyber security standards shall be complied with.

b) The Tenderer/Contractor shall cater for the communication infrastructure to connect the EMS's control system remotely

c) The Approved Gateway shall be owned, maintained, and operated by the Tenderer/Contractor.

d) Eskom shall have access to the EMS control system remotely.

e) The contractor shall provide two years online access to the embedded generations monitoring system.

f) The contractor must provide access to a remote website via Public Cellular-based communications network. Access to the website must be protected to avoid any unauthorized access. The Codes stipulate that this Gateway shall have at least three communication ports available exclusively for Eskom communications.

g) The PV and BES system shall be capable of reliably exchanging system status and data with the on-line communication system.

4.15.2 Personal Data Requirements

a) The Protection of Personal Information Act 4 of 2013 (POPIA) shall be always adhered to.

4.15.3 Network Infrastructure Requirements

a) Public Cellular-based communications networks to be used for the PV and BES system per requirements given in 240-7163097124 (DX TELECONTROL: USER REQUIREMENT SPECIFICATION FOR CELLULAR-BASED COMMUNICATIONS), unless instructed otherwise by Eskom. The initial site assessment should determine the available telecommunication communications networks options. Dx telecoms to be involved during the initial site assessment and communications networks solution selection.

4.16 Site requirements

4.16.1 Mechanical

4.16.1.1 Structure

The preferred option shall be a roof top or steel carport structures (that can be new or replaces the existing) which shall comply with the following requirements:

a) The roof or steel carport structures must be evaluated to determine if these are structurally sound to install the proposed PV panels and associated equipment. The following, but not limited to, must be considered when determining if the roof or steel carport structures are suitable:

- Live and dead loads of PV panels.
- Wind load of PV panels.

b) Enclosures shall be protected from water and dust ingress to a minimum of IP 55 as defined in IEC 60529 [39].

c) Outdoor enclosures shall be equipped to prevent condensation.

d) The structures shall be designed for harshest expected environmental conditions and corrosion protection requirements.

e) The structural material shall be minimum 6mm, 3CR12 or stainless steel or suitable corrosion resistive materials.

f) All enclosures both outdoor and indoor shall be protected against vermin and insects.

g) All enclosures shall be adequately strengthened, and facilities provided (in line with ISO standards) to ensure safe transportation, handling, and placement of the enclosures with the use of standard cranes (sling sets), moving and lifting equipment (forklifts).

a) The *Tenderer* may recommend additional protection and mitigation measures to protect the BESS (both outdoor and indoor) against any other significant risks as identified by the Tenderer. These mitigation measures shall be stated by the *Tenderer* in the tender submission.

b) The *Tenderer* shall submit a draft layout of the colour scheme, logos, and the wording to *Eskom* Corporate Identity Department for approval.

4.16.1.2 Locking Mechanism

Note: “High-risk” refers to areas where the probability of vandalism is high – leading to potential safety risks as well as non-technical losses.

a) The locking mechanism shall be suitable for “High Risk” areas.

b) All enclosure doors shall be recessed such that they are flush with the sides of the enclosure with no exposed hinges and gaps between moving parts are covered by plates (where possible).

c) The outside doors shall be re-enforced using additional steel strength members diagonally welded from corner to corner on the inside surface of the door.

d) Heavy duty hinges shall be fitted for the outside doors.

e) A four-point locking mechanism (i.e., at the top-centre, bottom-centre, left-centre, and right-centre) using bars operated by a heavy-duty door handle shall be fitted. Eskom to be consulted for site specific locking mechanism requirements.

f) Alternative mechanical door locking devices / mechanisms may be submitted for review by *Eskom*. The proposal for *Eskom’s* review shall include the operation of the mechanism as well as detailed information on the effectiveness of such system in preventing unauthorised access.

4.16.1.3 Thermal management

a) The enclosures shall include an HVAC or ventilation system designed to maintain ambient temperatures at levels acceptable to the OEM’s normal warranty conditions, conducive to maximise the operational life and efficiency, and as required maintaining the system capacity for all site-specific seasons/climatic conditions and for all planned small scale embedded generator uses.

b) The system must be fully automatic, and the supplier should state whether redundancy is included in the system.

c) Air-handling systems shall prevent dust intrusion.

4.16.1.4 Audible Noise

a) The maximum sound level generated from the system and any associated equipment supplied by the *Tenderer* under any output level within the system operating range, shall be limited to 65 dBA at 15 m in any direction from the site perimeter fence. No equipment may be installed in close proximity to offices as to cause disturbances to employees occupying offices.

4.16.2 Civil works

Reference specifications to be complied with by the Tenderer and all civil works to be signed off by an ECSA accredited professional engineer.

4.16.2.1 Earthworks

SANS 1200C [93] – Site clearance

SANS 1200M [96] – Civil Engineering Construction Roads (general)

SANS 1200DB [94] – Earthworks (Pipe trenches)

4.16.2.2 Concrete work

SANS 1200G [95] – minor and major concrete works construction.

SABS 0400-1990 [81] – The application of the national building regulations

4.16.2.3 Steel work

SANS 1431 [101] – Weldable structural steel

SANS 10162-1:2011 [88] – Limit states design of hot rolled steelwork

4.16.2.4 Pavement

TMH9 [121] – Flexible Pavement management system

SANS 1200MJ [97] – All kinds of segmented paving

4.16.2.5 Access road

TRH4 [122]: Structural design of flexible pavements for interurban and rural roads

TRH7 [123]: The use of bitumen emulsions in the construction and maintenance of roads.

4.17 LV system

All LV electrical system designs shall comply to SANS 10142 [87].

4.18 Other requirements

4.18.1 Maintenance base

1. With reference to par 2.5, the awarded *supplier* shall document a maintenance standard (MES) and a maintenance implementation standard (MIS) and all related documentation and (maintenance base artefacts (manuals, etc.), spares management and spares requirements) for the system care as per Eskom's prescribed formats, and hand it over during the commission of the plant. Where an existing Eskom equipment standard applies, the contractor shall ensure that this standard equipment is installed. These documents shall amongst others, cover the below items:

Parameters	Definitions
Asset identification	List and briefly describe key components of the system to which this maintenance requirements apply to and indicate exclusion / or boundaries if any.
Design intent	Maintenance requirements contribute to achieving the design intent, i.e., what the maintenance should sustain. Document the design intent at a high level, which maintenance will sustain, and against which the maintenance can be specified. If this is covered in other parts of the deliverables, you may make reference to such documents and applicable sections. The design intend should cover the following: • Purpose of the asset –functions that the asset should perform. • Performance of the asset and associated indicators – the intended reliability, maintainability, dependability, security etc.

Parameters	Definitions
	• Operating (physical and electrical) environment that the asset can tolerate – the intended operating environment. • Operating limits – limits within which the asset shall be operated (load etc). • Intended design life of the asset.
Maintenance Engineering Strategy	Maintenance activity determination: The maintenance activities and associated triggers (e.g., frequency, condition, duty etc.) shall be derived through failure modes effects and criticality analysis (FMECA) methodology. The maintenance activities from the FMECA study shall be collated and analysed further as per the maintenance the standard activity table.
	Asset and maintenance data: Asset data: Indicate the minimum asset data that must be captured in the Computerized Maintenance Management System (CMMS) to suitably describe the assets (e.g., Manufacturer Name, Serial Number, Manufacturer Type No., Manufacturing Year etc.) Maintenance data: Indicate the maintenance data that must be captured in the Computerized Maintenance Management System (CMMS) for condition monitoring / asset health.
	Maintenance task manuals (Maintenance procedures): Document the maintenance task manuals for the identified maintenance activities with step-by-step guides, test equipment, tools, and safety precautions to be observed by the maintenance crew whilst carrying out the said maintenance activities.
	Maintenance spares: List all the maintenance spares that are required to be kept in stock for the execution of the required maintenance activities.
	Facilities and training requirements: Indicate any special facilities, such as workshops that may be required to carry out the maintenance. List any special equipment / tools that may be required to carry out maintenance. Provide training curriculum for the execution of the maintenance activities.
Maintenance Execution Strategy	Asset classification: Asset classification is a consideration to factors during the operational life of the asset which may require that maintenance be carried out more frequently or contrariwise. Such factors may include Asset health, Environment, Usage / Duty Cycle and Functional importance (Criticality based on consequence of failure and Operational factors). Provide questions that can be used to classify the system for the purpose of influencing how often maintenance tasks should be carried out. Maintenance task selection: A maintenance task selection matrix incorporating the asset classification questions has been provided in the template to be prepopulated by the *Tenderer*. Functional equipment grouping:

Parameters	Definitions
	Some of the specified maintenance tasks may require outages. To minimise on outages, maintenance tasks for multiple assets in the same bay / circuit / substation can be grouped and executed during the same outage. Indicate which maintenance tasks should be group for execution during the same outage.
Asset health	Design life expectancy and failure issues: Indicate the design life of the system assets and factors that can contribute to the deterioration of the life of the asset. Where possible, indicate specific ageing material and components with scenarios/conditions, which can be measured or determined, and the associated impact on the remnant life. Condition assessment techniques: Indicate how the identified ageing materials and components should be assessed to indicate their health state. End of life criteria: Indicate the asset health index rating and asset end of life criteria.
Asset Performance	Performance measures: Indicate the system assets performance measures that should be monitored during the operational life of the assets (e.g., failure rate) and how such performance measures should be calculated. Failure causes: Indicate the potential failure modes and causes that should be observed to assess the effectiveness of the maintenance activities.
Note: Templates shall be provided by *Eskom* to fulfil the above requirements.	

5. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Sylvester Barei	Senior Manager Asset Creation
Ariseelan Moodley	Network Planning Manager
Rudi Jacobs	Asset Design Manager
Mashangu Xivambu	Senior Manager – Maintenance and Operations
Deon Boshoff -	Manager Specialised Maintenance
Xolisa Gabela	Zone Manager – Maintenance and Operations (Vaal zone)
Ben Klaassen	Zone Manager – Maintenance and Operations (Johannesburg zone)
Jason Kasper	Lands and Rights Manager
Mzwandile Magaqa	Zone Manager – Maintenance and Operations (Ekurhuleni and Tshwane Zones
Kith Maitisa	Safety, Health, Environment, Quality and Security Manager
Stephen Nkwane	Standards and Implementation Manager

Name and surname	Designation
Fezile Notununu	Portfolio Manager (Ekurhuleni, Tshwane, and Vaal zones) – Project Execution.
Paul Segwe	Portfolio Manager (Johannesburg zone) – Project Execution
Solly Matebula	Plant Manager
Charmaine Mare	Environment Manager (M&O)
Emelda Malima	Environment Manager (Asset Creation) – Acting

6. Revisions

Date	Rev.	Compiler	Remarks
September 2023	1	M Jansen van Vuuren	First issue
September 2023	2	M Jansen van Vuuren	4.16.1.1 a) Structure integrity requirements added

7. Development team

The following people were involved in the development of this document:

- Ariseelan Moodley
- Rudi Jacobs
- Deon-Louis Visagie
- Marius Jansen van Vuuren
- Barry Roux

8. Acknowledgements

- This document is based on the FUNCTIONAL SPECIFICATION FOR A SOLAR PHOTOVOLTAIC AND BATTERY ENERGY STORAGE SYSTEM: ESKOM ACADEMY OF LEARING – Document ID: 240-170001004