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|  | <b>User Requirement Specification</b> | <b>Distribution</b> |
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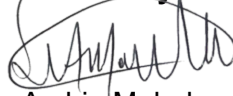
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### **CONTROLLED DISCLOSURE**

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## **1. INTRODUCTION**

This document is a User Requirement Specification (URS) for the

- supply,
- installation, and
- commissioning

of a ground-mounted PV system at the Freemantle Boy's High School

- provision of the warranty (material and service) on the complete installation for completed work for a set period.
- and other services as detailed here within.

The project will include supplying the material and installing as follows:

- Establishment of ground-mounted PV system,
- Erection of the PV mounting structure,
- Solar panel installation on top of the erected mounting structure.
- Batteries and inverters will be housed in a one "outdoor system" (all-in-one energy storage system), sized and installed outdoor next to the PV structures.
- Cover the "one outdoor system" with a galvanised cage.
- Fencing off the erected PV mounting structure and the "one outdoor system".
- Connecting the ground-mounted PV system output supply to various load points (or bulk load point) at the Freemantle Boy's High School.
- Making provision to export excess energy to the utility (Eskom) electrical network (Feed-back to the grid).

The primary purpose of this document is to provide guideline on the Eskom technical and functional requirements by which the Contractor will supply the material for and install the PV system as per the provided design package. Contractor shall provide all output information as described in the Techninical Evaluation Criteria, detailing how they comply with said requirements.

## **2. SUPPORTING CLAUSES**

### **2.1 NORMATIVE/INFORMATIVE REFERENCES**

#### **2.1.1 Normative**

*Refer to section 5 (Codes and Standards) for a supplementary list of normative references.*

[1] 240-83126800 Maintenance Standard Template

#### **2.1.2 Informative**

[2] ISO 9001 Quality Management Systems – Requirements

[3] Microgrid Preliminary Design Specification, SAN D201X-XXX, Unlimited Release, Michael J. Baca, Sandia National Laboratories

[4] 240-171000566 User Requirement Specification for Residential Solar Photovoltaic (PV) and Battery Energy Storage (BESS).

[5] 240-171000567 Techninical Evaluation Criteria for Residential Photovoltaic (PV) and Battery Energy Storage (BESS).

[6] 2 40-171000418 Major Equipment Requirements for Distribution Solar PV and BESS: SSEG and Microgrids

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## 2.2 DEFINITIONS

### 2.2.1 Disclosure Classification

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

### 2.2.2 Contractor

Typically **Contractor** shall be used for requirements during the execution and subsequent phases.

## 2.3 ABBREVIATIONS

| Abbreviation              | Description                       |
|---------------------------|-----------------------------------|
| AC                        | Alternating Current               |
| API                       | Application Programming Interface |
| BESS                      | Battery Energy Storage System     |
| BMS                       | Battery Management System         |
| CNC                       | Customer Network Centre           |
| CoC                       | Certificate of Compliance         |
| CT                        | Current Transformer               |
| DB                        | Distribution Board / Box          |
| DC                        | Direct Current                    |
| DCCB                      | DC Circuit Breaker                |
| DoD                       | Depth of Discharge                |
| ESS                       | Energy Storage System             |
| EV                        | Electric Vehicle                  |
| HMI                       | Human Machine Interface           |
| IT                        | Information Technology            |
| LCoE                      | Levelised Cost of Electricity     |
| LiFePO <sub>4</sub> / LFP | Lithium Iron Phosphate            |
| LoPP                      | Life of Plant Plan                |
| MCB                       | Miniature Circuit Breaker         |
| MCCB                      | Moulded Case Circuit Breaker      |
| MDB                       | Main Distribution Board           |
| MV                        | Medium Voltage                    |
| O&M                       | Operations and Maintenance        |
| OEM                       | Original Equipment Manufacturer   |
| PCS                       | Power Conversion System           |
| PGC                       | Point of Generator Connection     |
| PLC                       | Programmable Logic Controller     |
| PoC                       | Point of Connection               |
| PUC                       | Point of Utility Coupling         |

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|        |                                                 |
|--------|-------------------------------------------------|
| PV     | Photovoltaic                                    |
| RDP    | Remote Desktop Program                          |
| RTU    | Remote Terminal Unit                            |
| SAT    | Site Acceptance Test                            |
| SCADA  | Supervisory Control and Data Acquisition        |
| SLD    | Single Line Diagram                             |
| SoC    | State of Charge                                 |
| SPD    | Surge Protection Device                         |
| STC    | Standard Test Conditions                        |
| TCP    | Transmission Control Protocol                   |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| ToU    | Time of Use                                     |
| UPS    | Uninterruptable Power Supply                    |
| URS    | User Requirement Specification                  |
| UV     | Ultraviolet                                     |

### 3. OVERVIEW

Eskom Distribution has initiated a project to establish a ground-mounted PV system, consisting of Solar PV and battery backup, at Freemantle Boy's High School.

The objectives of the project are to:

- Support an Eskom strategic initiative: Reducing Eskom's carbon footprint and pursuing low carbon growth opportunities,
- Establish ground-mounted PV system when a loss of grid is detected (continuous supply),
- Provide renewable electricity to the facility for own consumption, by using the PV supply as a primary source of supply and the grid as a back-up supply.
- 
- Export excess solar energy to the grid.
- Support future peak energy shaving (load shifting/load reduction).

The purpose of this document is to define functional requirements and design constraints within which the Contractor will comply to the standards within the scope of work provided in the design package.

### 4. SYSTEM REQUIREMENTS

#### 4.1 PROJECT BASELINE

Along with the chosen major technology detailed below, include the following information as per below for the Freemantle Boy's High School ground-mounted PV system:

##### 4.1.1 Primary metrics:

| Metric | Value (minimum and useable) |
|--------|-----------------------------|
|--------|-----------------------------|

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Point of Generator Connection (PGC) Connected to various distribution boards in the school.

PV Modules

80\*640W monocrystalline

**NB: the following equipment below will be encased in the ESS**

Inverters

1\*50kW 3Phase Hybrid (Grid, PV and BESS integrated)

Inverter Continuous AC Output, per PGC

75.8A

Inverter Maximum Output Current (A)

83.4A

Inverter Continuous Passthrough (Direct Grid -> Essential), per PGC

200A

PV Peak Capacity (DC)

51.2kWp

Battery Usable AC Storage Capacity, at OEM recommended DoD, per PGC

7\*10.24kWh

Battery Continuous Power Output, per PGC

71kWh

Battery Chemistry

Lithium iron phosphate (LiFePO<sub>4</sub>)

Battery Minimum Cycle Life

25±2°C/0.2C/80%≥6000

Battery Voltage

HV

4.1.2 \*Hybrid inverters with a single DC bus and single inverter step shall be utilised. This is to avoid any future challenges whereby the facility's total PV and BESS inverters collectively surpasses the local municipality 1 MVA threshold, whereby a dedicated protected substation will be required.

4.1.3 The plant will supplement own consumption (as per design calculations).

4.1.4 Mono Crystalline silicon (c-Si) PV panels shall be utilised.

## 4.2 MODES OF OPERATION

The solution will support the following modes of operation, at each PGC:

4.2.1 Seamless and automatic **islanding** and **synchronisation**, to and from the grid in the event of an outage.

4.2.2 User-configurable **prioritisation of PV energy production** to either essential loads, or battery storage first, with the excess supplied to the other.

4.2.3 Support the feature to export any **excess energy to the PGC's grid-facing connection**, up to a specified power limit.

4.2.4 Support the option to utilise LV/MV connected CTs by the supply point, to enable control of energy exports.

4.2.5 Programmable behaviour to perform scheduled grid charge and discharges in a 24h period, using various setting setpoints and sensors / measurements. This, and similar functions, will allow for flexible **peak-shaving (or load reduction)** schedules to be programmed, and in addition allow for:

4.2.5.1 Limiting the rate of discharge,

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- 4.2.5.2 Setup of battery SOC limits to start and stop discharging, as per manufacturer's specification.
- 4.2.5.3 At least six programmable time-periods per day where different charge, discharge, thresholds, export enable / disable, and other settings can be automatically switched between, supporting a minute-resolution time setting (as per battery management system).
- 4.2.5.4 Load shaving during times of peak demand or high TOU tariffs, up to 100% of the BESS' peak AC discharge rate, sustained for its full capacity.

#### **4.3 KEY DESIGN CONSTRAINTS**

- 4.3.1 All PGCs and PUCs will be at three (3) phases.
- 4.3.2 The solution shall support a 100% unbalanced load.
- 4.3.3 All inverters, batteries, AC and DC combiner boxes, distribution boards, changeovers / bypass, and related equipment shall be installed at identified locations as per the design.
- 4.3.4 PGC(s) will be established, at the supply point(s).
- 4.3.5 The Contractor is responsible for the implementation, and any associated activities needed for laying the new cables required to establish the PGCs in full compliance with industry regulations and best practices.
- 4.3.6 All equipment shall be environmentally rated for the locations they are installed at. Outdoor equipment shall at minimum be IP65 rated, and indoor equipment at minimum IP21 rated.
- 4.3.7 All outdoor equipment shall be suitably rated for exposure to UV rays and highly corrosive conditions (e.g. rated / protected against rust). Where required, equipment shall be located to maximise protection against such elements and may necessitate dedicated covers.
- 4.3.8 No single failure of a component or control system shall cause a widespread loss of functionality.
- 4.3.9 Appropriately rated AC and DC fuses and / or MCBs, disconnectors and other protection and switching devices shall be utilised to ensure the safe operation of the plant, as well as to allow for safe commissioning, maintenance, fault finding, isolation and decommissioning.
- 4.3.10 OEM recommended design guidelines (including clearances) shall be followed. Where such recommendations are required by any statutory requirement, it shall be implemented.
- 4.3.11 Peak shaving, islanding, and any other modes of operation specified will apply at all PGCs and functionally supported at the PUCs (even if not implemented as part of this scope).
- 4.3.12 Compliance to the latest revision of all standards listed shall be required. Editions or revisions listed may have been updated.
- 4.3.13 Any cases, housing, cabinets, containers, cages, or similar, used to integrate equipment, shall be neutral in colour with no supplier, Contractor or other branding applied as part of this project.
- 4.3.14 All battery, inverter, and PV metrics provided are to be considered as minimum **usable** amounts, at the time of commissioning.
- 4.3.15 Final PGC(s) will be determined following the design package allocated to the contractor for construction.

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#### **4.4 STATUTORY, REGULATORY AND MUNICIPAL**

- 4.4.1 Proposals will comply will all statutory, regulatory, and municipal legislation and requirements, as well as Eskom standards, whether explicitly listed in this document or indirectly referred to.
- 4.4.2 Only equipment approved by the Local Munic shall be used (where required).
- 4.4.3 All electrical, architectural, structural, and engineering works will require sign-off by duly authorised engineers (e.g. ECSA registered) or other persons as required by law. Such sign-offs and documentation shall be for the Contractor's scope and will be provided to Eskom.
- 4.4.4 The Contractor shall have the PV installation approved by the personnel with the Green Card certification.
- 4.4.5 A Certificate of Compliance (CoC) will be required for all electrical works carried out.
- 4.4.6 All statutory, regulatory, and municipal requirements required to execute the scope of this document, shall be performed by the Contractor on behalf of Eskom. This includes the Local Municipality applications, electrical, structural, mechanical, civil, etc. sign-offs.
- 4.4.7 The Contractor shall inform Eskom at least one week in advance of their intention to submit any requirements listed in 4.4.3. Eskom shall have the option to review any such documents.

#### **4.5 PHOTOVOLTAIC MODULES**

- 4.5.1 Mono-Crystalline Silicon (c-Si) based PV modules shall be used.
- 4.5.2 The specified usable peak output power is applicable at the start of operations, post commissioning and handover.
- 4.5.3 To aid in spares holding, no more than two differently rated modules may be used.
- 4.5.4 To ensure efficient use of space, module efficiencies shall be at least 19% at a Standard Test Condition (STC) of irradiance 1000 W/m<sup>2</sup>, spectrum AM 1.5 and cell temperature of 25°C.
- 4.5.5 Outdoor junction boxes (DCCB, etc) shall be at least IP65 rated and installed under cover, unless reasonably not viable.
- 4.5.6 For each 18 to 24 cells within a module, a bypass diode shall be implemented.
- 4.5.7 Within the first year, the actual output power of PV modules shall be within 3% of its rated capacity.
- 4.5.8 Modules shall not decline in output power by more than 0.8% per year from year 2 to 20, this shall be warranted by the OEM.

#### **4.6 PV MOUNTING STRUCTURES**

The PV will be installed on a fixed slope ground-mounted steel-pole structure, allowing for optimum azimuth depending on the space availability on the selected area in the school.

- 4.6.1 PV modules shall be installed as per the manufacturer's recommendations, also considering the clamping zones of the panels.
- 4.6.2 Contractors shall execute as per provided design package for the ground mounted structure.
- 4.6.3 Mounting systems shall not compromise the integrity or stability of the structures they are mounted onto.
- 4.6.4 Only fixed mounting systems shall be utilised, i.e., no moving parts.

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- 4.6.5 North-facing structures shall be utilised first. Only if this is not sufficient, shall the opposing sides be used.

#### **4.7 50KW 70KWH OUTDOOR INTEGRATED ENERGY STORAGE SYSTEM (ESS):**

**(See also Annexure D)**

- 4.7.1 The system shall be able to work under humid conditions less or equal to 95%, temperature ranging from -20°C to 50°C, high ultraviolet (UV index  $\geq 10$ ), and maximum altitude of 1500m.
- 4.7.2 The system shall consist of the BMS management system, fire protection system, air-cooled unit, cabinet, PCS system.
- 4.7.3 The external front side of the cabinet shall have visible three indicator lights: cabinet malfunction indicator, cabinet DC indicator light, and cabinet AC indicator light. It shall also have the emergency stop switch, front heat dissipation window of cabinet and bottom baffle.
- 4.7.4 The external back side of the cabinet shall have power conversion system(inverter) heat dissipation, air conditioning system, and rear cooling window of cabinet.
- 4.7.5 The internal front side of the cabinet shall have visible stacked battery energy modules, energy storage power distribution unit (PDU) control box, and battery management unit (BMU).
- 4.7.6 The internal front side of the cabinet shall have visible fire-fighting system (hot aerosol), power conversion system (inverter), power conversion system (inverter) heat dissipation system heat dissipation air duct, and three-pin wall plug socket.
- 4.7.7 Inside the enclosure there shall be HV control box with three LEDs showing POWER, RUN, ALARM for Normal, Alarm, and Protection statuses.
- 4.7.8 The system shall have the following ports: Battery Management System ports such as debugging port, power conversion system communication port, parallel detection. Power conversion system ports such as power conversion system port and parallel detection. Ports such as display communication ports, air conditioning communication port, running indicator light, fault indicator, indicator light. Fan ports such as fan output, master-slave communication.
- 4.7.9 The system shall be installed and secured on a plinth as per civil design.

#### **4.8 INVERTERS**

**(See also Annexure B)**

- 4.8.1 Hybrid inverters shall exclusively be used in the solution, utilising a single internal DC bus and single DC to AC inverter step.
- 4.8.2 Only inverters producing pure sine waves shall be used.
- 4.8.3 Micro-PV inverters shall not be considered.
- 4.8.4 Inverter systems shall include their own built-in control and protection system.
- 4.8.5 Inverters shall support communication to external data-loggers using Modbus TCP, or Modbus RTU over TCP for real time data transmission. **As such, an Ethernet network interface shall be provided.**
- 4.8.6 Individual PV string level monitoring will be provided by the system.

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#### 4.9 AC LV RETICULATION, COMMS & OUTDOOR DB(S)

- 4.9.1 AC LV cabling using 2 x 50 mm<sup>2</sup> (or bigger) cables shall be installed from each PGC to the inverters (as grid-input). One of these cables should feed non-essential load and the other should feed back to the grid.
- 4.9.2 AC LV cabling using 1 x 50 mm<sup>2</sup> (or bigger) cable shall be installed from each inverter load / essential supply output to its respective PGC (load / essential load output).
- 4.9.3 All cables shall be suitably enclosed and protected from harsh environments, especially when entering buildings (e.g. traversing up the walls).
- 4.9.4 All cables shall be suitably protected by graded circuit breakers.
- 4.9.5 Inverters shall have both a DC disconnect, and AC disconnect switch (or multiples thereof) for isolation and maintenance purposes.
- 4.9.6 All AC terminals of the inverters shall be cabled to and available within the PGC / distribution boards, directly or through the main supply circuit.
- 4.9.7 All cabling must be run in cable ducts, cable trays and cable piping.
- 4.9.8 110mm HDPE Ducts shall be installed alongside the new LV cabling to provide for current and future communication between each PGC and its related equipment. A draw-wire shall be left within the ducts to aid in future communication cabling.

#### 4.10 BATTERY STORAGE

*(See also Annexure C)*

- 4.10.1 Lithium Iron Phosphate (LiFePO<sub>4</sub>, LFP) high voltage (HV) cells shall be utilised by the solution.
- 4.10.2 LFP batteries will comply with Eskom standard 240-170000103 - Lithium Iron Phosphate Batteries Standard.
- 4.10.3 Batteries will be subjected to daily cycling, barring less favourable weather conditions.
- 4.10.4 Cycling shall include micro-cycles, as demand and supply fluctuate from time to time.
- 4.10.5 Batteries shall support at least 5000 cycles until it reaches 80% of its original (full and usable) capacity. **The usable capacity at this (end) cycle-life shall be specified.**
- 4.10.6 An always online cell-balancing mechanism shall be available to ensure the battery's capacity is not compromised by an imbalance. No manual intervention should be required to balance the cells.
- 4.10.7 The storage solution shall be able to restart and continue normal operations following a complete discharge of all useable capacity, without any manual intervention. Therefore no "activation" of fully discharge batteries will be required.
- 4.10.8 The BESS shall support momentary over-current conditions, as example due to inrush currents from large, switched load equipment. **At minimum a 10% overload for 1 minute will be supported.** Batteries (or their configuration) and their inverters shall support this.
- 4.10.9 Batteries shall be stacked and / or housed in a suitable enclosure (racks), depending on the location.
- 4.10.10 All statutory and other mandatory requirements regarding safety, such as fire protection systems; and electrical fire, safety, incident response and security protocols shall be strictly adhered to, and in no way compromised by the solution.

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- 4.10.11 The battery BMS and controllers shall support communication to external data-loggers using Modbus TCP, or Modbus RTU over TCP for real time data transmission. As such, a network interface shall be provided.

#### **4.11 DC WIRING**

- 4.11.1 DC cables refer to the electrical wiring from solar PV modules to the input of the inverters, as well as wiring between batteries, chargers, and inverters.
- 4.11.2 It is common practice in solar PV designs to size the DC cable in such a way that annual average losses in DC cable corresponds to below or close to 1.5%. The minimum cable sizes shall include this current rating calculation as per provision made in the Bill of Quantities (BOQ). Additionally, all DC cables shall be:
- 4.11.2.1 UV-resistant and protected from UV light by appropriate protection; flexible to allow wind movement,
- 4.11.2.2 Qualified to PV1-F, and
- 4.11.2.3 Single conductor cable, double insulated.
- 4.11.3 To reduce electromagnetic injection in the solar PV system in an event of a lightning strike, wiring of DC-negative and DC-positive conductors shall be close and in parallel.
- 4.11.4 No live wiring, irrespective of voltage level, shall be exposed and thus reachable and subject to inadvertent contact.
- 4.11.5 DC wiring must not be run in the same wireway as the AC wiring.

#### **4.12 ENERGY METERING**

- 4.12.1 The Contractor shall install energy meters for each PGC. These meters will be located within or as close as possible to the inverter installations.
- 4.12.2 Two energy meters will be installed for each PGC, one on the grid (bi-directional) and one on the ground-mounted PV load supply side (essential load) (uni-directional). As such, at least two meters will be required in total.
- 4.12.3 Only Eskom approved meters, and where required, meter kiosks shall be used.
- 4.12.4 Communications to the meters will be via a modem. Meters located in the same cabinet will have their communication ports bussed and share a modem.
- 4.12.5 A suitable class 0.5 CT shall be installed for each meter, with ratio 300/5 A.
- 4.12.6 The voltage supply to each meter shall be protected by a circuit breaker.
- 4.12.7 The statistical metering installation shall be in accordance with 240-56364444, Standard minimum requirements for the metering of electrical energy and demand.
- 4.12.8 Data generated by these meters are required to be stored and accessible via the Eskom's metering system. Eskom shall install the required SIM cards to enable communication to its metering systems.
- 4.12.9 The meters shall be electrically connected as shown in D-DT-1000 Set 10. Existing enclosures may be utilised for the meters.

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#### **4.13 SAFETY**

In addition to those already detailed, the following safety and protection mechanisms will be required:

- 4.13.1 Earthing of electrical and electronic equipment to a reference earth point.
- 4.13.2 Disconnection and isolation mechanisms between all current-carrying conductors of the PV source, from all other conductors in the system.
- 4.13.3 Surge protection, earth leakage protection, reverse current detection/protection and circuit breakers for the power supply and power distribution network.
- 4.13.4 Shielding of all data communication and signal cables.
- 4.13.5 Physical security measures and locking mechanisms to prevent unauthorised access to all equipment.
- 4.13.6 Redundant / dual in-line safety devices such as interlocks, dead-grid-safety-locks, etc.,
- 4.13.7 Any emergency shutdown controls shall be suitably located and accessible as required.

#### **4.14 OPERATING**

- 4.14.1 The plant will be capable of operating with minimal user intervention (i.e., without operator intervention) under normal operation.
- 4.14.2 There will be no full-time plant operator required.
- 4.14.3 Full local control and monitoring of all equipment shall be possible, utilising equipment mounted/internal controls, displays, and / or separately wired physical controls (if needed).
- 4.14.4 The plant will have secure remote monitoring, viewing, and control capability.
- 4.14.5 The plant will be operated in-line with OEM recommendations and legal requirements.
- 4.14.6 The Contractor shall provide a detailed operating procedure.

### **5. CODES AND STANDARDS**

All required codes and standards shall be adhered to, including and not limited to:

#### **5.1 GENERAL**

- 5.1.1 SANS 10142-1 – The wiring of Premises – Part 1: Low voltage installation.
- 5.1.2 SANS 10142-1-2 The wiring of premises Part 1-2: Additional special requirements for low voltage small scale embedded generator installations connected to the grid. **(This standard has been withdrawn at the time of writing. Once re-published, compliance will be mandatory, even after tender award (but before handover of the project). Compliance to the latest draft is therefore encouraged at the tendering stage.)**
- 5.1.3 NRS 097-2-1 – Part 2 – Small-Scale Embedded Generation – Section 1: Utility Interface.
- 5.1.4 Grid Connection Code for Renewable Power Plants (RPPs) Connected to the Electricity Transmission system (TS) or the Distribution System (DS) in South Africa.

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## **5.2 ELECTRICAL**

### **5.2.1 PV Modules**

- 5.2.1.1 IEC 61215 Ed.2 - Crystalline silicon terrestrial photovoltaic (PV) module - Design qualification and type approval.
- 5.2.1.2 IEC 61646, Ed.2 - Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval.
- 5.2.1.3 IEC 61730-1 Ed.1.2 - Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction.
- 5.2.1.4 IEC 61730-2 Ed.1.0: Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing.
- 5.2.1.5 IEC 61701 Ed. 2 - Salt mist corrosion testing of photovoltaic (PV) modules.
- 5.2.1.6 IEC 62716 Ed. 1 - Photovoltaic (PV) modules - Ammonia corrosion testing.
- 5.2.1.7 IEC 60891 Photovoltaic devices - Procedures for Temperature and Irradiance Corrections to Measured I-V Characteristics.
- 5.2.1.8 IEC 61829 Crystalline Silicon PV Array - On-Site Measurement of I-V Characteristics.
- 5.2.1.9 IEC 61853: Performance testing and energy rating of terrestrial photovoltaic (PV) modules.
- 5.2.1.10 IEC 60068-2-78, Environmental testing – Part 2-78: Tests – Test Cab: Damp heat steady state.
- 5.2.1.11 IEC 60068-2-21, Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices.
- 5.2.1.12 IEC 61345, UV test for photovoltaic (PV) modules.
- 5.2.1.13 IEC 62093, Balance-of-system components for photovoltaic systems - Design qualification natural environments.
- 5.2.1.14 IEC 62548, Photovoltaic (PV) Arrays – Design Requirement.

### **5.2.2 Inverters**

- 5.2.2.1 IEC 62093 Ed. 1.0: Balance-of-system components for photovoltaic systems - Design qualification natural environments.
- 5.2.2.2 SANS 62109-1 Ed 1.0: Safety of power converters for use in photovoltaic power systems - Part 1: General requirements.
- 5.2.2.3 IEC 62109-2 Ed 2.0: Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters.
- 5.2.2.4 IEC 62116 Ed 2.0: Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures.
- 5.2.2.5 SANS 60730-1: Automatic electrical controls - Part 1: General requirements.

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- 5.2.2.6 IEC 61683: Photovoltaic systems - Power conditioners - Procedure for measuring efficiency.
- 5.2.2.7 SANS 61000 – 6 – 2, 3 and 4: Electromagnetic compatibility (EMC).
- 5.2.2.8 IEC 61727 Ed.2: Photovoltaic (PV) systems - Characteristics of the utility interface.
- 5.2.2.9 IEC 60364-7-712 Electrical Installations of Buildings: Requirements for Special Installations or Locations – Solar Photovoltaic power supply systems.
- 5.2.2.10 IEC 62103 Electronic equipment for use in power installations.

### **5.2.3 Storage**

- 5.2.3.1 240-170000103: Lithium Iron Phosphate Batteries Standard

### **5.2.4 Electrical Cabling**

- 5.2.4.1 IEC 62053 Requirements for cables for use in photovoltaic systems 2Pfg1169” by TÜV.
- 5.2.4.2 240-56227443: Requirements for control and power cables for Distribution Sites standard.

### **5.2.5 Earthing, Lighting and Surge Protection**

- 5.2.5.1 240-56356396 - Earthing and Lightning Protection Standard
- 5.2.5.2 IEC 60364-4-41 Low-voltage plants installation. Part 4-41 - Protection for safety – protection against shock.
- 5.2.5.3 SANS 10292 - Earthing of low-voltage (LV) distribution systems.
- 5.2.5.4 SANS 10199 - The design and installation of earth electrodes.
- 5.2.5.5 SANS 61312-3 - Protection against lightning electromagnetic impulse Part 3: Requirements of surge protective devices (SPDs).
- 5.2.5.6 SANS 10313 - Protection against lightning - Physical damage to structures and life hazard.
- 5.2.5.7 SANS 10200 – Neutral earthing medium voltage industrial power systems.
- 5.2.5.8 NRS 039 Part 1 and Part 2 - Surge arresters for use in distribution systems.
- 5.2.5.9 IEC 61009 Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's).

### **5.2.6 Metering and Measurements**

- 5.2.6.1 240-56227589: List of electronic devices to be used on Eskom Distribution Site standard.
- 5.2.6.2 240-56359083: Metering and Measurement Systems for Distribution Sites in Generation.
- 5.2.6.3 D-DT-1000: Meter Kiosk, 200kVA

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### **5.2.7 Performance Monitoring**

- 5.2.7.1 IEC 61724, Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis
- 5.2.7.2 IEC 61683, Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
- 5.2.7.3 IEC 60364-6 Ed. 1: Low Voltage Electrical installations.
- 5.2.7.4 IEC 62446 "Grid connected photovoltaic systems – Minimum requirements for System documentation, commissioning tests & Inspections"
- 5.2.7.5 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.
- 5.2.7.6 ISO 9847, solar energy - Calibration of field pyrometers by comparison to a reference pyrometer. / BS 7621:1993 Method for calibrating field pyrometers by comparison to a reference pyrometer
- 5.2.7.7 ISO 9060, solar energy - Specification and classification of instruments for measuring hemispherical solar and direct solar radiation.
- 5.2.7.8 ISO/TR 9901, solar energy - Field pyrometers – Recommended practice for use.
- 5.2.7.9 IEC 61725, Analytical expression for daily solar profiles

### **5.3 CONTROL AND INSTRUMENTATION**

- 5.3.1 IEC 61724 Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis;
- 5.3.2 IEC 61850-7 Communication networks and systems for power utility automation - Part 7-420: Basic communication structure – Distributed energy resources logical nodes;
- 5.3.3 IEC 62381 – Factory acceptance test (FAT), site acceptance test (SAT), and site integration test (SIT);
- 5.3.4 IEC 62382 Electrical and Instrumentation loop check activities;
- 5.3.5 IEC 62337 – Commissioning of electrical, instrumentation & control systems;
- 5.3.6 EIA/TIA 568 – Standard for structured cabling;
- 5.3.7 EIA/TIA 569 – Standard for communication pathways and spaces;
- 5.3.8 EIA/TIA 607 – Standard for grounding and bonding of communication cabling;
- 5.3.9 TIA/EIA 485: Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems;
- 5.3.10 TSB-89-A Application Guidelines for TIA/EIA-485-A;
- 5.3.11 SANS 10142-1-2012 – The Wiring of Premises Part 1: Low-voltage installations;
- 5.3.12 SANS 10340-1 Installation of telecommunication cables part 1: Fibre optic cables in buildings;
- 5.3.13 SANS 10340-2 Installation of telecommunication cables part 2: Outdoor fibre optic cables;
- 5.3.14 SANS 60794-1-1 – Optical fibre cables - Part 1-1: Generic specification – General;

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- 5.3.15 SANS 60794-1-2 – Optical fibre cables - Part 1-2: Generic specification - Basic optical cable test procedures;
- 5.3.16 SANS 61312 – Protection against lightning electromagnetic impulse;
- 5.3.17 SABS 1411: Parts 2-6 – Materials of Insulated Electric Cables and Flexible Cords;
- 5.3.18 SANS 60947-7-1 and 60947-7-2 – The terminal blocks for the junction box terminations;
- 5.3.19 SANS 60429 – Degree of protections provided by enclosures (IP);
- 5.3.20 240-56227443 Requirements for Control and Power Cables for Power Stations Standard, sections 3.2.7, 3.6, 3.7, 3.8.7, 8, tables 16, 17, 18 & 19;
- 5.3.21 240-56355754 - Field Instrument Installation Standard, section 3;
- 5.3.22 240-56355815 - Field Instrument Installation Standard Junction Boxes and Cable Termination;
- 5.3.23 240-56355731 Environmental Conditions for Process Control Equipment Used at Power Stations Standard;
- 5.3.24 240-56355541 Control System Computer Equipment Habitat Requirements Guideline;
- 5.3.25 32-373 Information Security – IT/OT and Third-Party Remote Access Standard;
- 5.3.26 240-55410927: Cyber Standard for Operational Technology;
- 5.3.27 240-79669677: DMZ designs for Operational Technology;
- 5.3.28 240-64038621: Remote Device Communication Standard for Data Retrieval and Remote Access.

#### **5.4 CIVIL**

- 5.4.1 Southern African Steel Construction Handbook (Red Book):
- 5.4.2 SANS 10160-1
- 5.4.3 SANS 10160-3
- 5.4.4 SANS 10162-1
- 5.4.5 SANS 10160 – Basis of structural design and actions for buildings and industrial standards.
- 5.4.6 SANS 10162-1 – The structural use of steel Part 1: Limit states design of hot-rolled steelwork
- 5.4.7 SANS121:2011 Ed2 – Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
- 5.4.8 SANS 2001 – CS1 Ed.1.01 – Construction works Part CS1 – Structural steel works.
- 5.4.9 SANS 1921-3 Ed.1 – Construction and Management requirements for works contracts – Part 3 Structural steel works
- 5.4.10 SANS 1200H Ed3 – Standard specification for Civil Engineering construction - Structural steel work installation
- 5.4.11 SANS 1200HC - Standardized specification for civil engineering construction Section HC: Corrosion protection of structural steelwork
- 5.4.12 240- 56364535 Architectural technical specification for structures and other buildings
- 5.4.13 240- 56364545 Structural design and engineering standard

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## 6. SITE DESCRIPTION

### 6.1 LOCATION

The Area/Building site is located under the following address/coordinates:

- GPS Coordinates: 31°42'29.19"S & 27°11'16.29"E
- Location: Freemantle Boy's High School Eastern Cape, South Africa



*A-Office block*

*(B-to F) - classrooms*

*G-Hall*

### 6.2 SCOPE OF WORKS

Contractor to:

- 1) Do site assessment as per provided drawings.
- 2) Verify that the drawings are correlating with the site
- 3) Identify cable routing to various Distribution Boards (DBs')
- 4) Verify the size of the main circuit breaker and ensure proper protection cascading with other DBs' as per design provided.

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5) Once site verification is completed the Contractor to execute scope as follows:

**6) The Contractor to:**

- a) Install two ground-mounting structure and install 80\*640Wp modules in a portrait orientation.
- b) Wire the 4mm<sup>2</sup> DC cables to the DC combiner box, and then to the inverter.
- c) Contractor to install a bidirectional meter next to the transformer.
- d) Wire the 50mm<sup>2</sup> +/-100m AC cable from the bidirectional meter to the disconnect switch inside the AC kiosk. Wire from the disconnect to the inverter.
- e) Wire the 50mm<sup>2</sup> AC cable from the inverter output to the AC distribution board.
- f) Wire the 16mm<sup>2</sup> cable from the new AC Distribution board to the grid's main AC distribution board.
- g) Wire the 4mm<sup>2</sup> cable from the new AC Distribution board to the grid's AC in the office room (A).
- h) Wire the different 4mm<sup>2</sup> cables from the new AC Distribution board to the grid's AC in the classrooms B to H, separately.
- i) Contractor to distribute to different blocks as per table below:

| From Block   | To Block     | Cable size mm <sup>2</sup> | Approx. Distance (m) | Source MCB (A) | ATS (A) |
|--------------|--------------|----------------------------|----------------------|----------------|---------|
| ESS AC kiosk | C            | 16mm <sup>2</sup>          | ±70m                 |                | 80      |
| C            | ESS AC Kiosk | 50mm <sup>2</sup>          | ±70m                 |                |         |
| ESS AC kiosk | A            | 4mm <sup>2</sup>           | ±77m                 |                | 80      |
| ESS AC kiosk | B            | 4mm <sup>2</sup>           | ±80m                 |                | 80      |
| ESS AC kiosk | C            | 4mm <sup>2</sup>           | ±150m                |                | 80      |
| ESS AC kiosk | D            | 4mm <sup>2</sup>           | ±240m                |                | 80      |
| ESS AC kiosk | E            | 4mm <sup>2</sup>           | ±245m                |                | 80      |
| ESS AC kiosk | F            | 4mm <sup>2</sup>           | ±240m                |                | 80      |
| ESS AC kiosk | G            | 4mm <sup>2</sup>           | ±300m                |                | 80      |

- j) Contractor to install an 150A three phase 4 pole Automatic Change Over switch next to newly installed kiosk to bypass the PV Solar system during its failure and automatically supply the load with Grid supply.
- k) Contractor to do all tests and commission the PV installation.
- l) Contractor to provide CoC of the newly installed system to Eskom
- m) Contractor to provide as built drawings to Eskom upon project completion should there be scope changes during construction.

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- n) Supply and install mount a 1\*9L AVD Lithex Portable Fire Extinguisher as per Annexure A.
- o) **Existing School Wiring:** Contractor to assess the existing DB wiring and work on the DB only if it is wired as per required standard. Should the DB be substandard, the contractor shall notify the Clerk of Works and communicate such findings with the design engineer.

## **7. WARRANTIES**

### **7.1 BASE AND RELATED WARRANTIES**

- 7.1.1 All OEM guarantees and warranties of equipment and material used within the system shall be transferred to Eskom.
- 7.1.2 The solution shall be offered with a minimum of 12 months base warranty where the Contractor warrants Eskom that the furnished *equipment* and *materials* and the completed project are fit for the purpose of producing and storing electricity in accordance with the requirements and are free from defects in workmanship and materials.
- 7.1.3 All *equipment* and *material* with OEM or other warranty periods exceeding the base warranty shall be detailed by the Contractor and honoured until their expiry.
- 7.1.4 A *workmanship* warranty of minimum of 12 months, after handing over of the installation to Eskom, shall be provided, with the Contractor responsible for addressing and rectifying any defects or issues related to the installation within this period.
- 7.1.5 Warranties shall include the repair of all failures due to design, manufacturing, installation, and otherwise latent defects (i.e., excluding failure due to mishandling or misuse of the equipment by Eskom or its appointed representatives).
- 7.1.6 The Contractor shall repair and / or replace, free of charge, any component or part that is proven to be defective during its warranty period.
- 7.1.7 Any charges associated with the repair / replacements and shipping of defective equipment from site or the Contractor's local office, to and from the works of the principal (OEM) (including overseas) shall be for the Contractor's expense.
- 7.1.8 The Contractor shall keep record of and manage all OEM product warranty agreements and claims on behalf of Eskom. Eskom should be provided with the copy of these warranty agreements.
- 7.1.9 The Contractor shall clearly state the O&M care regime that should be adhered to, to ensure that the warranties are not impacted.

### **7.2 PERFORMANCE WARRANTY**

- 7.2.1 Performance warranties guarantee aspects of the system's operation such as capacity (power and energy), availability and efficiency for the duration of the performance warranty period which should be guaranteed as per the requirements.
- 7.2.2 The intended and permissible use of the equipment installed shall be clearly described to avoid disputes on warranty, particularly when the utilisation of a particular system has been changed from initial intent.

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- 7.2.3 Under the **capacity warranty**, the Contractor shall guarantee that the solution is able to deliver the minimum power and energy capacities as specified in the requirements, with degrading factors not exceeding those directly specified, or indirectly through references to normative standards.
- 7.2.4 Under the **availability warranty**, the Contractor shall specify the minimum availability of their solution. This shall be calculated as the weighted peak power output of units out of service, with respect to the overall installed capacity, over the different time periods. An availability warranty of at least **98%** shall be provided.

### **7.3 RESPONDING TO FAULTS**

During the execution of works and subsequent warranty periods, the Contractor (through the manufacturers or agents) shall provide a 24-hour response time to Eskom. The extent of the response shall, as a minimum, comprise:

- 7.3.1 Official notification of the problem being reported.
- 7.3.2 Suggested solution (provided in writing and recorded on the non-conformance / field failure reporting system) within two weeks.
- 7.3.3 The replacement of faulty equipment or material.
- 7.3.4 It is required that the manufacturer or representative has trained support staff available within the province.

## **8. SCOPE OF WORK**

The following is a summary of further expectations, in addition to those listed elsewhere in this document.

### **8.1 TENDERING PHASE**

Tendered proposals shall include the following technical documentation:

- 8.1.1 Completed technical evaluation criteria.
- 8.1.2 Final design package will be given to Contractor for construction. This shall include relevant power, capacity, etc. calculations of all major electrical equipment, inclusive of the inverters, batteries, AC and DC cabling.
- 8.1.3 Priced BOQ( Bill of Materials), BOM (Bill of Materials), to include detail of individual inverters, BESS / batteries, PV modules, integration equipment, any communication system, metering, major cable, structural works, etc.
- 8.1.4 BESS specifications, including the minimum guaranteed usable capacity at its DC interface and cycle lifetime, with recommended DoD.
- 8.1.5 Calculated solar DC and AC peak power capabilities, per PGC.
- 8.1.6 Preliminary logic diagrams of the control systems.
- 8.1.7 Basic project schedule, from contract signing to handover.
- 8.1.8 Details of how each of the *modes of operations* are achieved by the solution.
- 8.1.9 Detail of any risks and necessary mitigations that the has been identified.
- 8.1.10 All other documentation as required by the tender.
- 8.1.11 List of spares & quantities that should be kept by Eskom

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## **8.2 ENGINEERING & DESIGN**

- 8.2.1 The Contractor shall install as per provided complete detailed designs, for all subsystems, and the overall solution as specified in the requirements.
- 8.2.2 All drawings shall be provided by Eskom and As-Builts will be provided by Contractor upon project completion.

**The Contractor shall create and obtain the Employer's approval for the following plans (may be in parts combined if approved by Eskom):**

- 8.2.3 Where applicable, revised as built drawings.
- 8.2.4 Final design drawings of all subsystems and the overall interconnected solution should the changes come with an approval of the design engineer.
- 8.2.5 MV and / or LV switchgear arrangements for all PGCs.
- 8.2.6 If available, map of the communications for the microgrid showing communication networks, pathways, devices, IP addresses, ports, protocols, and cyber security implementations involved in the microgrid control system.
- 8.2.7 If available, detailed description of communication hardware for the microgrid as well as the communication mediums and devices used (wireless, fibre optics, media convertors, etc.).
- 8.2.8 Details of how the control system ties and operates with every control enabled device in the microgrid (PV, storage, switches, ATS, breakers, etc.).
- 8.2.9 Details on how both system-wide and device-level control algorithms work, including associated diagrams and documentation.
- 8.2.10 Installation manuals, instruction manuals and operation guides for all equipment and subsystems.
- 8.2.11 All control and protective settings.
- 8.2.12 An emergency response plan shall be developed and documented, outlining procedures for system failures, safety incidents, and critical events. Eskom teams shall receive training on these procedures.
- 8.2.13 Software documentation.
- 8.2.14 Constructability plan and time schedule, detailing how the various subsystems will be installed. This plan shall also give assurance that the overall project is obtainable within the given timeframe / schedule.
- 8.2.15 Other project documentation that would reasonably be required to document the construction and operation of the microgrid.
- 8.2.16 As-built drawings and documentation upon final project acceptance, including that of all electrical and structural components installed and alterations made.

## **8.3 O&M PLANS (MAY IN PARTS BE COMBINED IF APPROVED BY ESKOM):**

- 8.3.1 A list of recommended spare parts and consumables, including part numbers and sources for procurement, shall be provided for routine maintenance and replacements.
- 8.3.2 Instruction manuals for the operating of system.
- 8.3.3 Annual operating & maintenance plan for the plant.

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## **8.4 EXECUTION**

- 8.4.1 The Contractor shall supply, deliver, install, and commission all equipment required by the solution.
- 8.4.2 During such time all Eskom Life-Saving rules, as well as site rules shall be complied with.
- 8.4.3 Prior to the Contractor's commissioning and start-up and / or functional livening tests, the following will be provided at least one week in advance for the Employer's review and comment:

- 8.4.3.1 A final commissioning plan / procedure detailing the required steps to commission the plant.

- 8.4.3.2 A plant readiness checklist that will be utilised to ensure the safe start of the plant.

- 8.4.3.3 A start-up and shutdown sequence to be followed, including a shutdown procedure in the event of an emergency or catastrophic failure.

- 8.4.4 Upon completion of the project, all areas that were subject to any civil, mechanical, structure, or otherwise temporarily altered state to perform the works, shall be returned to its original state.

- 8.4.5 Care shall be taken to ensure that excavations do not endanger the foundations of adjacent buildings.

- 8.4.6 All the necessary precautions shall be taken to prevent subsidence of soil which could result in damage to foundations.

- 8.4.7 Where excavations may unavoidably endanger the stability of fences or other structures, such structures shall be removed and replaced to the satisfaction of the owner(s).

### **8.4.8 Route selection:**

- 8.4.8.1 The cable trench shall be installed as marked and surveyed within the road reserve at 1.2m from the property boundary and extend a maximum width of 1 m.

- 8.4.8.2 The thermal resistivity of the soil at the proposed cable depth shall be tested in accordance with SANS 10198-5. A minimum of one sample per km shall be tested unless agreed otherwise by the Project Engineer.

- 8.4.8.3 Any bridge crossings shall be designed and approved by a professional civil/structural engineer and shall include precautions to cater for the expansion and vibration of the bridge. The cable bridge crossing shall be designed to ensure the risk of cable theft is mitigated at all costs and that the spare ducts are catered for where required.

- 8.4.8.4 Where space limitations and/or the presence of other underground services within the road reserve prevent the positioning of the trench and joint bays between the road and the adjacent property boundary, consideration may need to be given to the positioning of the trench and joint bays under the road surface.

### **8.4.9 Excavation shall include:**

- 8.4.9.1 Excavations shall include digging and drilling holes of between 0.8 m – 2 m for normal applications and > 2 m for special applications as in D-DT-0332. All excavations shall be kept covered or barricaded, if not attended to, in a manner accepted by Employer to prevent injury to people or livestock.

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- 8.4.9.2** The Contractor shall notify the Clerk of Works upon completion of the excavation for the pole foundation. No shuttering, reinforcing steel or concrete shall be placed until the Clerk of Works has inspected the excavations and acknowledge his approval.
- 8.4.9.3** Removal of excavated Black Turf or any other soil unsuitable for backfilling and transporting it to borrow pits.
- 8.4.9.4** The excavated material shall be disposed of in borrow pits or a suitable place, indicated by the Employer site representative or the Employer environmental representative.
- 8.4.9.5** The Contractor shall make his own arrangements for the provision to dispose of the excavated material on such a disposal place.
- 8.4.9.6** Free haul shall be the distance within a radius of 1.5 km from the pole position.
- 8.4.9.7** Limited haul shall be the first 1km beyond the end of the free haul distance by the shortest practicable route.
- 8.4.9.8** Long haul shall be the remainder of the distance beyond the limited haul by the shortest practicable route.

**8.4.10 Backfilling shall include:**

- 8.4.10.1** Compacting the excavated pole hole where for normal application backfill material will be used.
- 8.4.10.2** For special applications where the pole planting depth exceeds 2m, backfilling shall include the use of soil cement to reinforce the pole foundation.

**8.4.11 Importing soil shall include:**

- 8.4.11.1** The Contractor shall be responsible for supplying imported soil. If not otherwise specified, the imported soil shall be in accordance with SANS 1200.
- 8.4.11.2** The imported soil shall not contain notable quantities of organic matter or stones of average dimension exceeding 150mm.

**8.4.12 Trenching and Backfilling:**

- 8.4.12.1** Where the surface to be excavated requires a permanent re-instatement by a local authority or Contractor, it is preferable to use a tar cutter or any other suitable tool.
- 8.4.12.2** LV cable trench details shall be in accordance with D-DT-0854- Annexure B shall be consulted for any deviations. Where a change in trench level is necessary, the bottom of the trench shall rise or fall gradually and smoothly.
- 8.4.12.3** For road or rail crossings, the depth of cable shall be increased in accordance with D-DT-0854 or as per the wayleave conditions. Trenches shall be kept as straight as possible and the bending radius shall be tight, however never less than the minimum bending radius of the cable given in table 1.

**Table 1: Installation minimum bending radii for LV cables**

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| Installation minimum bending radii for LV cables |                         |                         |                     |                                       |                                       |
|--------------------------------------------------|-------------------------|-------------------------|---------------------|---------------------------------------|---------------------------------------|
| <10 mm <sup>2</sup>                              | 10 - 25 mm <sup>2</sup> | 25 - 40 mm <sup>2</sup> | >40 mm <sup>2</sup> | Unarmoured Cable ≥ 40 mm <sup>2</sup> | Unarmoured Cable ≥ 40 mm <sup>2</sup> |
| 3xD                                              | 4xD                     | 6xD                     | 8xD                 | 8xD                                   | 10xD                                  |
| <b>Notes:</b>                                    |                         |                         |                     |                                       |                                       |
| 1) D refers to the overall diameter of the cable |                         |                         |                     |                                       |                                       |

8.4.12.4 The transport, storage and the use of explosives shall comply with the provision of the Explosives Act No 26 of 1956 and the Explosives Regulations of the Occupational Health and Safety Act No 85 of 1993. A copy of blasting permits issued to workmen and permits issued to the Contractor to cover the purchase, storage and transport of explosives shall be given to the project clerk of works.

8.4.12.5 The material excavated from the trench shall be placed adjacent to the trench. This shall be done in such a manner as to prevent interference or damage to adjacent hedges, trees, drains or other property along the cable route. Where site conditions make this impossible, the excavated materials may, with the approval of the Design Engineer, be removed from the site and returned for re-filling the trench on completion of laying. All surplus material, from whatever source, shall be disposed of by the Contractor.

8.4.12.6 The trench bedding and blanket soil around the cable shall be in accordance with SANS 10198-8 requirements for bedding. A sieve having a mesh size of no larger than 12 mm may be used to sift the excavated soil. Alternatively, suitable bedding and blanket soil shall be imported.

8.4.12.7 The trench backfilling shall be in accordance with SANS 10198-8 and D-DT 0854.

8.4.12.8 The bedding soil shall be installed and compacted prior to cable installation. Blanket soil shall be compacted using hand compaction tools. Backfill material shall be compacted in layers of maximum thickness 200 mm. The level of compaction (see D-DT-0854) shall be measured at appropriate intervals in accordance with 240-45683927.

8.4.12.9 SANS 10198-5 contains descriptions of the various types of soils and their respective suitability for cable surround soil (bedding and blanket soil) and backfill material.

8.4.12.10 A dynamic cone penetrometer (DCP) detailed in 240-45683927 may be used to measure the level of compaction. Warning tape (see D-DT-8013) shall be installed at a depth of 300 mm below natural ground level in accordance with D-DT-0854.

8.4.12.11 The backfilling requirements and required level of compaction for road surface reinstatement shall be in accordance with the relevant road agency specification and shall take precedence over the requirements of D-DT-0854 and 240-45683927.

8.4.12.12 All pavements, roads and driveway crossings shall be re-instated to their original state.

8.4.12.13 When re-instating surfaces, a compacted crown shall protrude 50 mm above the natural ground level (NGL) must be catered for to allow for erosion.

#### **8.4.13 Cable Installation:**

Refer to the attached standard 240-56030367 (Rev 2 section 3.9.6 to 3.9.12)

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#### **8.4.14 Cable Transportation and Storage:**

Refer to the attached standard 240-56030367 (Rev 2 section 3.10.1.4)

#### **8.4.15 Wall Mounted:**

The installation shall be carried out in accordance with services standard 240-75661043 and the relevant drawings on D DT 1000 series. They shall be installed on the common boundary or in the middle of customer properties which it is supplying, with the doors parallel to street as per and D-DT1010 sheet 2.

### **8.5 SITE ACCEPTANCE TESTING**

- 8.5.1 The Contractor shall provide a full site acceptance testing (SAT) plan, for review, comment, and approval by the Employer.
- 8.5.2 Each component and subsystem shall be tested and proven to comply with the requirements.
- 8.5.3 The Employer shall witness all tests performed and sign each as such. Note that witnessing does not indicate compliance.
- 8.5.4 Eskom reserves the right to perform its own tests internally to verify that any requirement is met.
- 8.5.5 Once completed, the Contractor shall compile a SAT report for review and acceptance by the Employer.
- 8.5.6 As a minimum (where installed) testing shall include the following. Test may be combined where feasible:

#### **Outdoor integrated Energy storage system (ESS):**

- 8.5.6.1 Insulation resistance test
- 8.5.6.2 Soil resistance test and results to be shared with the engineer.
- 8.5.6.3 Test all the devices as per the system's user manual/specification.

#### **BESS:**

- 8.5.6.4 System full capacity.
- 8.5.6.5 System round trip efficiency.
- 8.5.6.6 Sustained maximum power output (loads to be determined by the Employer).
- 8.5.6.7 Sustained charging current / power.

#### **Inverters:**

- 8.5.6.8 Output voltage.
- 8.5.6.9 Output frequency.
- 8.5.6.10 Solar DC input to AC output efficiency under various loads.

#### **PV modules (individual or strings), including:**

- 8.5.6.11 Open-circuit voltage.

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8.5.6.12 Short-circuit current.

8.5.6.13 Operating current under different conditions (compared to STC).

8.5.6.14 Resistance to earth (measure at and between earth nodes).

8.5.6.15 Insulation testing, where applicable.

## **8.6 TRAINING**

8.6.1 Training forms a pivotal part of this project's scope, and hence it is of the utmost importance that Contractors take due consideration in formulating training schedules, material, etc.

8.6.2 Training shall be provided as indicated below, per the number of sessions and attendees for each.

8.6.3 Training shall be accompanied by reference material and as-built drawings and designs of components and systems presented.

8.6.4 The following training types will be provided. Where feasible and upon Eskom's acceptance, training types may be combined.

### **8.6.4.1 Generic Design, System Overview, and Hardware Training**

Sessions: 2 Sessions with up to 10 attendees each (skills transfer to students & teachers).

Comprehensive system-wide training on all hardware components including the BESS, inverters, solar modules, cabling, protective, control and monitoring devices / systems, communication cabling and hardware. This training will also cover other aspects relating to the design, operations and monitoring of this and general PV and microgrid systems:

- Provide an overview of the entire solar and battery storage system, including key components such as solar panels, inverters, batteries, and monitoring systems.
- Safety training, to ensure all staff are aware of potential hazards and safety protocols associated with solar and battery installations. Handling of emergency situations and crisis management related to the solar and battery system.
- Conducting site-specific assessment for this design, incl. shading analysis, and system design to optimize energy production.
- Electrical and mechanical integration of solar and battery systems with existing infrastructure.
- Battery management principles, including charging and discharging cycles, maintenance, and safety procedures.
- Grid interconnection requirements, utility requirements, regional permitting processes, documentation requirements, etc.
- Quality control measures and testing procedures to ensure system reliability.
- Inverter settings, integration to battery BMS, paralleling, different modes of operation, scheduling, etc.
- Basic operations and monitoring on the system.

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#### **8.6.4.2 Network Administration Training**

Sessions: 1 Session with responsible teacher and the care taker

- Deep-dive training into all communications deployed as part of the solution, including serial, parallel and ethernet-based.
- Detail how data is collected and aggregated, alarms generated, controls sent, etc.
- Typical failure modes (what can be expected if the system fails) and backup and recovery options.
- User management.
- Visual local and remote indications and controls.

#### **8.6.4.3 Operation and Maintenance training**

Sessions: 1 Session with the responsible teacher and caretaker

Day-to-day monitoring, control, and maintenance activities. Detail of all errors, warnings, notices or other alerts and data that should be acted upon. Any specific warranty requirements.

- Typical equipment failure modes (how they fail) and replace / recovery options shall be included.
- Use of monitoring systems to
  - track system performance,
  - identify trends and potential efficiency improvements, and
  - conduct routine maintenance tasks like cleaning, inspections, and system troubleshooting.
- Comprehensive O&M training that includes detailed instructions on system operation, maintenance, and troubleshooting procedures.
- Outline the warranties for each system component, discussing the process for warranty claims.
- Emergency response plan.

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9. REVISIONS

| Date     | Rev. | Compiler     | Remarks     |
|----------|------|--------------|-------------|
| May 2026 | 0    | Tsidi Damane | First Issue |
|          |      |              |             |
|          |      |              |             |

10. DEVELOPMENT TEAM

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11. ACKNOWLEDGEMENTS

Luntu Mgaga

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## **Annexure A: 1\*9L AVD Lithex Portable Fire Extinguisher**

|                        |                           |
|------------------------|---------------------------|
| Extinguisher AVD Type  | LithEX AVD9               |
| Brim Full              | 11,614 ml                 |
| Fill Volume AVD Agent  | 9000 ml                   |
| Approx. Weight Agent   | 9.9 kg                    |
| Approx. Weight of Unit | 16.4 kg                   |
| Cylinder dia.          | 182 mm                    |
| Cylinder height        | 528 mm                    |
| Unit Height            | 627 mm                    |
| Handle                 | Metal                     |
| Hose                   | Yes                       |
| Base                   | Green PP                  |
| Bracket                | Wall Hanger               |
| Fire rating            | 13A                       |
| PED/PE(S)R Certified   | Yes                       |
| Kitemark EN3 Certified | Yes                       |
| MED/ME(S)R Certified   | Yes                       |
| NTA 8133 Pass          | Yes                       |
| Propellant             | Nitrogen (He Tracer) bar* |
| Operating Pressure     | 15/ bar*                  |
| Operating Temperature  | +5°C to +60°C             |
| Approx. Discharge Time | 126/s                     |
| Discharge Range/m      | 1.5-2.0                   |
| Packaged unit L*W*H    | 208X191X660 mm            |
| Units per Box          | 1                         |
| Box Dimensions         | N/A                       |

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## Annexture B: 50kW Hybrid Inverter technical specification

| <i>Description</i>                             | <i>Quantity</i>      |
|------------------------------------------------|----------------------|
| <b>Battery Input Data</b>                      |                      |
| Battery Type                                   | Lithium-ion          |
| Battery Voltage Range(V)                       | 160-800              |
| Max. Charging Current(A)                       | 50+50                |
| Max. Discharging Current(A)                    | 50+50                |
| Charging Strategy for Li-ion Battery           | Self-adaption to BMS |
| Number of Battery Input                        | 2                    |
| <b>PV String Input Data</b>                    |                      |
| Max. PV access power(W)                        | 80000                |
| Max. PV Input Power(W)                         | 60000                |
| Max. PV Input Voltage(V)                       | 1000                 |
| Start-up Voltage(V)                            | 180                  |
| PV Input Voltage Range(V)                      | 180-1000             |
| MPPT Voltage Range(V)                          | 150-850              |
| Full Load MPPT Voltage Range(V)                | 450-850              |
| Rated PV Input Voltage(V)                      | 600                  |
| Max. Operating PV Input Current(A)             | 36+36+36+36          |
| Max. Input Short-Circuit Current(A)            | 55+55+55+55          |
| No. of MPP Trackers/No. of Strings MPP Tracker | 4/2+2+2+2            |
| Max. Inverter Backfeed Current to The Array    | 0                    |
| <b>AC Input/Output Data</b>                    |                      |
| Rated AC Input/Output Active Power(W)          | 40000                |
| Max. AC Input/Output Apparent Power(VA)        | 44000                |

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|                                                  |                                |
|--------------------------------------------------|--------------------------------|
| Rated AC Input/Output Current(A)                 | 58                             |
| Max. AC Input/Output Current(A)                  | 58                             |
| Max. Continuous AC Passthrough (grid to load)(A) | 200                            |
| Max. Output Fault Current (A)                    | 116                            |
| Max. Output Overcurrent Protection (A)           | 192.3                          |
| Rated Input/Output Voltage/Range(V)              | 230/400V 240/415V 0.85Un-1.1Un |
| Grid Connection Form                             | 3L+N+PE                        |
| Rated Input/Output Grid Frequency/Range          | 50Hz/45Hz-55Hz                 |
| Power Factor Adjustment Range                    | 0.8 leading-0.8 lagging        |
| Total Current Harmonic Distortion THDi           | <3% (of nominal power)         |
| DC Injection Current                             | <0.5%In                        |
| <b>Efficiency</b>                                |                                |
| Max. Efficiency                                  | 97.60%                         |
| Euro Efficiency                                  | 97.00%                         |
| MPPT Efficiency                                  | >99%                           |
| <b>Equipment Protection</b>                      |                                |
| DC Polarity Reverse Connection Protection        | Yes                            |
| AC Output Overcurrent Protection                 | Yes                            |
| AC Output Overvoltage Protection                 | Yes                            |
| AC Output Short Circuit Protection               | Yes                            |
| Thermal Protection                               | Yes                            |
| DC Terminal Insulation Impedance Monitoring      | Yes                            |

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## **Annexture C: LiFePO4 Battery Specification**

| <b>Category</b> | <b>Parameter</b>      | <b>Value</b>        |
|-----------------|-----------------------|---------------------|
| General         | Battery type          | LiFePO4             |
|                 | Nominal Energy        | 10.24kWh            |
| Electrical      | Nominal Voltage       | 51.2V               |
|                 | Voltage Range         | 44.8 -57.6V         |
|                 | Capacity              | 200Ah               |
|                 | Max. Charge current   | 100A                |
|                 | Max Discharge current | 100A                |
| Performance     | Cycle life            | >=6000 cycles       |
|                 | Efficiency            | >=95%               |
| Environment     | Charge Temperature    | 0 to 55°C           |
|                 | Discharge Temperature | -20 to 55°C         |
|                 | Humidity              | <=95%               |
| Mechanical      | Weight                | Approx. 95 -100kg   |
|                 | Protection            | IP20                |
| Communication   | Interfaces            | CAN/RS485           |
| System          | Scalability           | Up to 15 – 32 units |

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## Annexture D: Integrated Energy Storage System (ESS)

|                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The integrated energy storage system (as a combo unit) will function as outdoor all-in-one unit is to convert the high-voltage direct current generated by external photovoltaic modules into low-voltage direct current and store it in the battery through an inverter. It will also convert the direct current of the battery into alternating current through the inverter for use by the load or integration into the power grid. |
| The product will function as outdoor energy storage, including but not limited to storing the energy generated by solar power during the day for use at night or when the battery is low; Balancing the load of the power grid, peak shaving and valley filling, and improving the stability and reliability of the power grid.                                                                                                        |
| The inverter, battery and power dispatching is offered in a single containing unit (combo).                                                                                                                                                                                                                                                                                                                                            |
| <b>Appearance description</b>                                                                                                                                                                                                                                                                                                                                                                                                          |
| <i>The combo unit consists of:</i>                                                                                                                                                                                                                                                                                                                                                                                                     |
| Energy storage module box                                                                                                                                                                                                                                                                                                                                                                                                              |
| Energy storage power dispensing unit (PDU) control box                                                                                                                                                                                                                                                                                                                                                                                 |
| 3-Phase Hybrid inverter                                                                                                                                                                                                                                                                                                                                                                                                                |
| Inverter heat dissipation duct                                                                                                                                                                                                                                                                                                                                                                                                         |
| Cabinet malfunction indicator                                                                                                                                                                                                                                                                                                                                                                                                          |
| Cabinet DC indicator light                                                                                                                                                                                                                                                                                                                                                                                                             |
| Cabinet AC indicator light                                                                                                                                                                                                                                                                                                                                                                                                             |
| Emergency Stop Switch                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Front heat dissipation window of cabinet                                                                                                                                                                                                                                                                                                                                                                                               |
| Bottom baffle                                                                                                                                                                                                                                                                                                                                                                                                                          |
| PCS/inverter heat dissipation                                                                                                                                                                                                                                                                                                                                                                                                          |
| Air conditioner system                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Rear cooling window of cabinet                                                                                                                                                                                                                                                                                                                                                                                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Energy Storage Module Box</b>                                                                                                                                                                                                                                                                                                                                                                                                       |
| <i>The energy storage consists of:</i>                                                                                                                                                                                                                                                                                                                                                                                                 |
| Mounted bracket of energy storage module box                                                                                                                                                                                                                                                                                                                                                                                           |
| Energy storage module box handle                                                                                                                                                                                                                                                                                                                                                                                                       |
| Energy storage module box Bat- (battery negative terminal)                                                                                                                                                                                                                                                                                                                                                                             |
| Energy storage module box Bat+ (battery positive terminal)                                                                                                                                                                                                                                                                                                                                                                             |
| Air outlet of energy storage module box                                                                                                                                                                                                                                                                                                                                                                                                |
| Battery management unit (BMU) panel                                                                                                                                                                                                                                                                                                                                                                                                    |
| Fan/Communication connection port                                                                                                                                                                                                                                                                                                                                                                                                      |
| Ground wire screw hole                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Energy storage power dispensing unit (PDU) control box</b>                                                                                                                                                                                                                                                                                                                                                                          |

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|                                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>The PDU consists of:</i>                                                                                                                    |
| PDU control box mounted bracket                                                                                                                |
| PDU control box handle                                                                                                                         |
| DC terminal Bat+ (battery positive terminal)                                                                                                   |
| DC terminal Bat- (battery negative terminal)                                                                                                   |
| Miniature circuit breaker                                                                                                                      |
| Power indicator light                                                                                                                          |
| Running indicator lamp                                                                                                                         |
| Fault indicator light                                                                                                                          |
| Load side P- (Load negative terminal)                                                                                                          |
| Load side P+ (Load positive terminal)                                                                                                          |
| WIFI signal module                                                                                                                             |
| BMS communication port                                                                                                                         |
| Inverter communication port                                                                                                                    |
| Load end circuit breaker                                                                                                                       |
| Air conditioning module communication port                                                                                                     |
| Auxiliary Port                                                                                                                                 |
| Fan output port                                                                                                                                |
| Repair power supply port                                                                                                                       |
| Ground wire screw hole                                                                                                                         |
|                                                                                                                                                |
| <b>Working Mode</b>                                                                                                                            |
| The high voltage control box, the PDU, has three LED lights "Power", "Run" and "Alarm", that should operate as follows:                        |
| Under normal conditions, "Power" and "Run" will be on, and "Alarm" will be off.                                                                |
| "Alarm" will be on when the overvoltage protection, undervoltage protection, overcurrent protection and temperature protection has occurred.   |
| <b>Power Dispensing Unit (PDU) Ports</b>                                                                                                       |
| The PDU has the following ports with the following functionality and terminal numbering:                                                       |
| 8 Terminal Dual BMS CAN: with 1-2 for BMS debugging; 4-5 for inverter communication; 6&8 for parallel detection                                |
| 8 Terminal Dual Inverter CAN: with 4-5 for inverter communication; 6&8 for parallel detection                                                  |
| 4 Terminal COM 1: with 1-2 for display communication; 3-4 for 24 VDC                                                                           |
| 6 Terminal COM 2: with 1-2 for air conditioning communication; 3 for running indicator light; 4 for fault indicator light; 5 for ground (GND-) |
| 4 Terminal FAN: with 1-2 for fan output; 3-4 for master-slave communication                                                                    |

| Functional Parameters |          |
|-----------------------|----------|
| Description           | Quantity |
| Nominal Energy        | 71 kWh   |
| Nominal Voltage       | 716.8 V  |

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|                              |                                                                                                |
|------------------------------|------------------------------------------------------------------------------------------------|
| Nominal Capacity             | 100 Ah                                                                                         |
| Cell Type                    | LFP                                                                                            |
| Standard Charge Voltage      | 806.4 V                                                                                        |
| Max Charge Current           | 100 A                                                                                          |
| Discharge Cut-Off Voltage    | 645 V                                                                                          |
| Max Discharge Current        | 100 A                                                                                          |
| Maximum working altitude     | 2000 m                                                                                         |
| Working humidity range       | ≤95% (no condensation)                                                                         |
| Cooling method               | Air-cooled                                                                                     |
| Cycle Life                   | 25 ± 2°C/0.2C/80% ≥6000                                                                        |
| Range of working temperature | -20 ~ 50°C                                                                                     |
| Fire Fighting System         | Aerosol                                                                                        |
| Dimensions (D*W*H)           | 1066mm*1174mm*1561mm                                                                           |
| Weight                       | ≈850 kg                                                                                        |
| Warranty (minimum)           | 10 years                                                                                       |
| Battery system               | BMS management system, fire protection system, air-cooled unit, cabinet, PCS (inverter) system |

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