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1. INTRODUCTION

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

- design,
- supply,
- installation,
- commissioning,
- maintenance and operations (for a set period),
- and other services as detailed here within,

of a microgrid at the Eskom's Brackenfell Engineering complex. The project will include:

- Establishment of <u>two</u> LV microgrids, one for the M- and one E-Block buildings
- Solar panel installation atop the M-Block carports
- Battery installations

The primary purpose of this document is to provide detail of the site's existing infrastructure, along with detail the Eskom technical and functional requirements by which the final installed solution shall comply with. Tenders shall provide design proposals, 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] <240-xxxx> Task Manual Template

2.1.2 Informative

[3] ISO 9001 Quality Management Systems – Requirements

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

2.2 DEFINITIONS

2.2.1 Disclosure Classification

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

2.2.2 Tenderer, Contractor

Typically, **Tenderer** shall be used to indicate a requirement and tender stage, whereas **Contractor** shall be used for requirements during the design/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

CoC	Certificate of Compliance
CT	Current Transformer
DB	Distribution Board / Box
DC	Direct Current
DCCB	DC Circuit Breaker
DoD	Depth of Discharge
EV	Electric Vehicle
HMI	Human Machine Interface
IT	Information Technology
LCOE	Levelised Cost of Electricity
$LiFePO_4$ / 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
PGC	Point of Generator Connection
PLC	Programmable Logic Controller
POC	Point of Connection
PUC	Point of Utility Coupling
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 microgrid, consisting of Solar PV and battery backup, at its Brackenfell Engineering Complex.

The objectives of the project are to:

a) Support an Eskom strategic initiative: Reducing Eskom's carbon footprint and pursuing low carbon growth opportunities,
b) Establish microgrids when a loss of grid is detected (uninterrupted supply),
c) Provide renewable electricity to the Eskom Brackenfell Complex for own consumption,
d) Export to grid excess solar energy not utilised.
e) Support future peak energy shaving (load shifting),

The scope of this project is part of a two-phase greater initiative. This project will see solar PV installed on the carports on the M-Block and enabling microgrid(s) for the surrounding loads. A second Eskom-run project is planned to establish a similar scope for the larger central carports and surrounding buildings.

The purpose of this document is to define functional requirements and design constraints within which tenderers are to propose compliant designs.

The scope of this URS is limited to the M-Block Carports.

4. SYSTEM REQUIREMENTS

4.1 PROJECT BASELINE

Along with the chosen major technology detailed further here within, the following forms the baseline of the project:

4.1.1 Primary metrics:

Metric	Value (minimum and useable)
Point of Generator Connection (PGC)	2x LV (M-Block and E-Block buildings)
Inverters	***Hybrid (PV and BESS integrated)
Inverter Continuous AC Output, per PGC	100 kW
Inverter Peak AC Output for 5 seconds, per PGC (PV + BESS)	120 kW
Inverter Continuous Passthrough (Direct Grid -> Essential), per PGC	400 A
PV Peak Capacity (DC)	200 kWp Total, 100kW per PGC
Battery <u>Usable</u> AC Storage Capacity, at OEM recommended DoD, per PGC	70 kWh
Battery Continuous Power Output, per PGC	70 kW
Battery Chemistry	Lithium iron phosphate ($LiFePO_4$)
Battery Minimum Cycle Life	5000 Cycles (see 4.9.6)
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 whereby the complex's total PV and BESS inverters collectively surpasses the City of Cape Town's 1 MVA threshold, whereby a dedicated protected substation will be required.

4.1.3 The plant will supplement own consumption by 200 kWp x 365 days x 4.5 sun-hours = 328 MWh/year.

4.1.4 Crystalline silicon (c-Si) PV panels shall be utilised, producing 8,200 MWh in 25 years, and resulting in a carbon savings of 8,774 tons[1].

4.1.5 A scheduled maintenance and care period of 1 year with monthly intervals are included in the scope.

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 MV connected CTs at the complex's PUCs, to enable control of energy exports. This will not be implemented at this time, however the solution must support this, should it be required in the future.

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** schedules to be programmed, and in addition allow for:

4.2.5.1 Limiting the rate of discharge,

4.2.5.2 Setup of battery SOC limits to start and stop discharging at,

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,

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 new inverters, batteries, AC and DC combiner boxes, distribution boards, (optionally) changeovers / bypass, and related equipment shall be installed below the M-Block buildings carports.

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[1] 1 MWh = 1.07 tons of CO_2 savings, Eskom Integrated Report 2014

4.3.4 Two new PGCs will be established, one each at the distribution boards of the M-Block and E-Block buildings.

4.3.5 The Contractor is responsible for the design, 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 Within each building's distribution boards a new PGC will be created. The allocation of loads between grid and essentials will be affected by the Contractor, as detailed in Section 6.

4.3.7 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.

4.3.8 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.

4.3.9 All outdoor inverter and battery installations shall be protected by a lockable wire mesh security cage, suitably treated for a highly corrosive environment. This cage shall fully enclose the area, whilst allowing for all O&M activities to occur unobstructed and with no added risks.

4.3.10 No single failure of a component or control system shall cause a widespread loss of functionality.

4.3.11 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.

4.3.12 OEM recommended design guidelines shall be followed wherever possible. Where such recommendations are required by any statutory requirement, it shall be implemented.

4.3.13 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).

4.3.14 Compliance to the latest revision of all standards listed shall be required. Editions or revisions listed may have been updated.

4.3.15 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.

4.3.16 All battery, inverter, and PV metrics provided are to be considered its minimum **usable** amounts, at the time of commissioning.

4.3.17 Final PGC(s) will be determined following a review and analysis of proposals received.

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 City of Cape Town shall be used (where required).

4.4.3 All electrical, structural, and engineering works will require sign-off by duly authorised engineers 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 A Certificate of Compliance (CoC) will be required for all electrical works carried out.

4.4.5 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 City of Cape Town applications.

4.4.6 The Contractor shall inform Eskom at least one weeks in advance of its 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 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^2, 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 of the carports, 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 INVERTERS

4.6.1 Hybrid inverters shall exclusively be used in the solution, utilising a single internal DC bus and single DC to AC inverter step.

4.6.2 Only inverters producing pure sine waves shall be used.

4.6.3 String and micro-PV inverters shall not be considered.

4.6.4 Inverter systems shall include their own built-in control and protection system.

4.6.5 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.**

4.6.6 Inverters shall support a dedicated generator input, capable of accepting the inverter's full rated continuous power output. This input shall also support the charging of batteries.

4.6.7 Individual PV string level monitoring will be provided by the system.

4.7 AC LV RETICULATION, COMMS & OUTDOOR DB(S)

4.7.1 AC LV cabling supporting at least 500 A shall be installed from each PGC to the inverters (grid-input).

4.7.2 AC LV cabling supporting at least 500 A shall be installed from each inverter load / essential supply output to its respective PGC (load / essential -output).

4.7.3 All cables shall be suitably enclosed and protected from harsh environments, especially when entering buildings (e.g. traversing up the walls).

4.7.4 All cables shall be suitably protected by graded circuit breakers.

4.7.5 Inverters will have both a DC disconnect, and AC disconnect switch (or multiples thereof) for isolation and maintenance purposes.

4.7.6 A 500A (or larger) three phase AC changeover / bypass shall be included for each PGC. This shall be installed within either the outdoor distribution boards, or existing building's board.

4.7.7 All AC terminals of the inverters shall be cabled to and available within the outdoor distribution boards.

4.7.8 Thee (3) standard 16 A three pin SANS164-1 sockets shall be provided within the distribution boards, wired to the load/essential side, and protected by overcurrent and earth leakage protection.

4.7.9 To support future initiatives, the design shall make space provision for all necessary cable terminals, routing, protective devices, and any other required components for the items listed below. Within designs, such spaces shall be clearly labelled as "future":

4.7.9.1 One EV charging circuit for each carport (i.e. three circuits), supplied from the <u>grid-side</u> source and capable of at least 200 A per circuit.

4.7.9.2 Interface to a future generator input(s).

4.7.10 110mm HDPE Ducts shall be installed alongside the new LV cabling to provide for current and future communication between <u>each</u> PGC and its outdoor equipment. A draw-wire shall be left within the ducts to aid in future communication cabling.

4.7.11 Within the 110mm HDPE pipes, a 10-pair or bigger signalling cable shall be provided between each set of outdoor generation equipment and respective PGC. I.e. two cables will be required. The supplied cables shall be suitably rated for the installation environment. At each end the cable shall be labelled and terminated onto suitable terminals. This cable shall support future low bandwidth communication (e.g. RS-485) as well as direct contactor operating (minimum 230Vac @ 10A).

4.7.12 A 12-core multimode cable shall be provided between <u>each</u> set of outdoor generation equipment and the M-Block Server Room, i.e. two cables will be required. Furthermore, dedicated 32/26mm (outer/inner diameter) HDPE pipes shall be installed. The supplied cables shall be suitably rated for the installation environment.

4.7.13 All fibre cores shall be spliced onto a suitably mounted fibre patch panel, on both sides. The Server Room shall utilise a 19" rackmount fibre patch panel.

4.7.14 A dedicated communications enclosure shall be situated at each PGC's set of **outdoor equipment**, with suitable routing options between it and all installed networking equipment as required for the SCADA solution (see section 4.16).

4.7.15 Two (hardwired) dry contacts to signal minor / non-urgent and major / urgent alarms shall be made available within the outdoor installation. Space shall be provisioned for a Metacom MC402 modem to which these contacts shall be connected. Alternatively, two sets of such contacts may also be provided at two locations (linked to each PGC), each providing space for a MC402 modem. Eskom shall free-issue the MC402 modems.

4.8 PV MOUNTING STRUCTURES

The most common installation for roof top PV system is fixed system, where the modules are installed in a fixed angle and fixed azimuth, depending upon the type of roof (flat, inclined) and orientation of buildings.

In the case of additive installation in sloping roofs such as the Brackenfell carports, modules are assembled with a metal structure above the existing roof covering with a standoff of several mm for cooling purposes (Figure 1). The metal structure consists of three main components: roof brackets, mounting rails and module fasteners. Mounting rails are either anchored to the roof structure or attached with hooks directly to the roof covering.

Figure 1 - Typical Mounting system on Carport rooftop

4.8.1 PV modules shall be installed as per the manufacturer's recommendations.

4.8.2 Tenders shall propose a mounting system that will enable the required capacity and performance requirements to be met, throughout the lifespan of the solution.

4.8.3 Mounting systems shall not compromise the integrity or stability of the structures they are mounted onto. As such, the tenderer shall perform any required structural analysis to ascertain this and strengthening if required.

4.8.4 Only fixed mounting systems shall be utilised, i.e., no moving parts.

4.8.5 All three sides of the carports facing primality North shall be utilised first. Only if this is not sufficient, shall the opposing sides be used. However, should the opposing side be used, a detailed analysis will be required to suitably oversize the overall installation to meet the peak power, annual yields, and performance requirements.

4.8.6 Refer to Appendix G: Carport Frames for a section view of the existing carports. Contractors will be required to do their own structural analysis for the equipment they plan to install.

4.9 BATTERY STORAGE

4.9.1 Lithium Iron Phosphate (LiFePO4, LFP) cells shall be utilised by the solution.

4.9.2 LFP batteries will comply with Eskom standard 240-170000103 - Lithium Iron Phosphate Batteries Standard. **A completed schedule B shall be returned as part of the tender package.**

4.9.3 All unspecified schedule A options of 240-170000103 shall be as per the intended application, as per the tenderer's proposal. Deviations to this shall be clearly noted by the tenderer, with special care taken to highlight differences between the design options.

4.9.4 Batteries will be subjected to daily cycling, barring less favourable weather conditions.

4.9.5 Cycling shall include micro-cycles, as demand and supply fluctuate from time to time.

4.9.6 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**.

4.9.7 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.

4.9.8 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.

4.9.9 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. Both batteries (or their configuration) and their inverters shall support this.

4.9.10 Batteries shall be stacked and / or housed in a suitable enclosure, depending on the location.

4.9.11 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.

4.9.12 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.

4.10 DC WIRING

4.10.1 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.

4.10.2 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. Additionally, all DC cables shall be:

4.10.2.1 UV-resistant and protected from UV light by appropriate protection; flexible to allow wind movement,

4.10.2.2 Qualified to PV1-F, and

4.10.2.3 Single conductor cable, double insulated.

4.10.3 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.

4.10.4 No live wiring, irrespective of volage level, shall be exposed and thus reachable and subject to inadvertent contact.

4.11 SYSTEM EFFICIENCIES

The Tenderer shall state the following efficiency metrics of their system. These will include any internal parasitic loads:

4.11.1 Round trip efficiency of the BESS, measured at the AC side.

4.11.2 Efficiency of the solar inverter, represented as both a maximum efficiency, and the Euro or CEC (California Energy Commission) weighted efficiency, which considers typical usage patterns.

4.11.3 The weighted average efficiency (Euro or CEC) shall be 97% or higher.

4.12 ENERGY METERING

4.12.1 The Contractor shall install statistical metering (energy meters) for each PGC. These meters will be located within or as close as possible to the outdoor inverter installations.

4.12.2 Two statistical meters will be installed for each PGC, one on the grid and one on the load/essential side. As such four 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 .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.

4.12.10 Refer to Appendix A: Metering Bill of Materials, for the required modems, meters, and CT's to use. Equipment not otherwise listed shall be suitably selected.

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 SCADA equipment.

4.13.6 Redundant / dual in-line safety devices such as interlocks, dead-grid-safety-locks, etc., as required.

4.13.7 Any emergency shutdown controls shall be suitably located and accessible as required by relevant municipal rules and statutory requirements.

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.

4.15 MONITORING, CONTROL & INSTRUMENTATION (SCADA)

4.15.1 An HTML5-based webserver supervisory, control and data acquisition (SCADA) system will be provided, allowing for full visibility, setting changes and control of the system.

4.15.2 The SCADA system shall be an "commercial off the shelf" product and not a custom-developed solution.

4.15.3 The SCADA system shall be provided with an unlimited license, supporting the integration of future inverter, battery, and related equipment/devices, to a minimum of at least 5x times the installation described within this document.

4.15.4 Access to the SCADA system shall support:

4.15.4.1 A virtual terminal, in that the hosting hardware can be access by remote desktop (RDP) through its network interface.

4.15.4.2 Secure, authenticated, and authorised access to the full HTML5 SCADA interface through any external web browser.

4.15.4.3 A read-only HTML5-based webpage detailing the live, daily, weekly, monthly, and yearly energy and power metrics, along with a graphic / HMI of the system with live data and power flows. This will be made available to all on-site staff to create awareness of this and similar systems.

4.15.5 The SCADA solution shall be based on open-standards (enabling plug-and-play) for scalability and communications between components. No proprietary protocols shall be used.

4.15.6 All equipment will be monitored and controlled through the SCADA system, inclusive of inverters, chargers, battery BMS and controllers, monitoring, and management systems.

4.15.7 Communication dongles will be installed on equipment, if required to enable the SCADA functionality. **NB:** No internet connection shall be allowed to enable any functionality detailed in this section.

4.15.8 The SCADA system will eliminate any direct access needed to any equipment to monitor, affect setting changes, or perform controls.

4.15.9 The system shall support a detailed, low-level data and information view of each component / device (e.g., inverter, BESS, control units, etc.) in the system. This level should expose all possible data from, and send settings and controls to, the equipment / devices.

4.15.10 The system shall be configured with basic aggregation of data to obtain a holistic view of the plant's performance.

4.15.11 A live HMI for quick visual diagnosis of the system and support control inputs shall be provided.

4.15.12 A user-configurable HMI using dynamic graphic objects along with real-time and historic data (continuously updating). Objects' position, colour and text shall support dynamic data from the plant shall be supported.

4.15.13 The SCADA systems shall support aggregated controls, whereby system-side settings and setpoints (such as for power imports / exports and timeframes) can be set, and on/off / start/stop functions be made.

4.15.14 An alarm annunciator showing both historic and current alarms shall be provided. Such function shall have a mechanism to acknowledge alarms, preferably with an operator's comment.

4.15.15 An integrated data-logger will be provided to store long-term data and shall include all power, energy, capacity, health, environmental, voltage and current metrics as relevant to each subsystem.

4.15.16 Generation and exporting of historical plant data in .csv or .xls (Excel) file formats shall be supported.

4.15.17 An application programming interface (API) shall be available to both remotely retrieve any data within the SCADA system and to perform control functions.

4.15.18 The SCADA system provide at least 2 different user groups. 'Basic' users should have 'read only' and no-control access while an 'advanced' user should have read, control and configuration rights.

4.15.19 Each user group shall have unique authentication details (username and password) for logging into the SCADA webserver.

4.15.20 Basic users shall support at least 3 concurrent sessions, whereas the 'advanced' users should be allowed one session at a time to prevent parallel controls or changes to settings.

4.15.21 The SCADA systems shall not form part of any internal system control-loops, or in any way be required for the normal and safe operation of the entire plant.

4.15.22 No part of the system shall require access to the internet to operate. Only direct connections to the equipment will be utilised. As required, Modbus RTU / Serial ports need to be encapsulated within TCP/IP utilising Serial Device/Port Servers and directly made available to the SCADA system.

4.15.23 All significant system events, such as a loss of grid, environmental exceedances, safety triggers, switchgear operations, etc shall be communicated via email to internal maintenance staff, utilising an Eskom provided SMTP gateway. Note that this functionality cannot be used by external parties providing maintenance services, in which case a separate service must be catered for.

4.16 SCADA HARDWARE

4.16.1 The SCADA solution will be provided with all hardware, including computers, screens, input devices, integrated data-loggers, network & communication equipment, power supplies, etc. required.

4.16.2 The SCADA system will be installed inside the M-Block Server Room, within a provided 19" server rack. The solution shall utilise no more than 20U within the provided server rack.

4.16.3 The SCADA system will be logically laid out with the following provided equipment physically segregated and each suitable labelled:

4.16.3.1 Server / computer system which shall preferably be 19" rackmount

4.16.3.2 Electronic network equipment (switches, router, data-loggers, protocol, or media convertors, etc.)

4.16.3.3 Power supply, power cabling and associated equipment, (MCBs, fuses, SPDs, etc.)

4.16.3.4 Communication cabling and associated infrastructure (E.g., splice trays (if needed), termination blocks, etc.)

4.16.4 The SCADA system hardware shall be suitably specified to support the integration of future inverter, battery, and related equipment/devices, to a minimum of at least 5x times the installation described within this document.

4.16.5 All communication links from the outdoor equipment will be installed within ducts which terminate within the M-Block Server Room.

4.16.6 All communication originating from each set of outdoor equipment shall be aggregated onto an Ethernet router/switch and each linked through a fibre pair to the Server Room. The Server Room shall have the required equipment to interface between the fibre links and SCADA hardware.

4.16.7 Only managed Ethernet equipment shall be used. As such no unmanaged media convertors (Fibre to Copper convertors) may be used.

4.16.8 Electronic equipment installed inside the Server Room panel will be suitably rated for continuous operations in a limited-controlled environment subjected to temperature ranges between 0˚C to +35˚C.

4.17 SECURITY

4.17.1 Access to any equipment (physically, virtually, or logically) that poses any risk to the health and safety of the public or otherwise persons not involved with this solution, shall be suitably protected.

4.17.2 Access to internal networks (whether non-routable or routable such as IP) shall be suitably protected from any external access, whether to protect against malicious or opportunistic bad actors, or any other seemingly harmless 3rd party.

4.17.3 The solution shall comply with 240-55410927 - Cyber Security Standard for Operational Technology.

4.18 METEOROLOGICAL INSTRUMENTATION

A meteorological system providing climatic data shall be provided and include:

4.18.1 1 x high-accuracy calibrated solar reference cells installed **per module tilt and orientation**. The cell will have the same technology and type as the installed PV modules and installed at the centre of the PV array. The calibration of the reference cell must perform according to IEC 60904-2: Photovoltaic device – Part 2: Requirements for reference solar devices.

4.18.2 1 x shielded ventilated thermocouple installed at the centre of the PV array to measure the ambient temperature with a measurement accuracy of ±1°C (Pt 100 class B according to IEC 60751).

4.18.3 1 x thermal sensor installed at the back sheet of the PV module, centre to the PV array to measure module surface temperature with a measurement resolution up to ± 1°C (Pt 100 class B according to IEC 60751).

4.18.4 The data from each set of instruments will be communicated using **Modbus** (over Ethernet) to the SCADA's integrated data-logger of each zone for processing and storage. Where sensors do not have inherent capabilities to communicate using Modbus, suitable convertors shall be installed in the outdoor enclosures before being combined onto the Ethernet link back to the M-Block electrical room.

4.18.5 The reference cell and PT 100 (module back - on special case) temperature sensors data will be used directly to evaluate the plant performance.

4.18.6 The measured meteorological parameters will be averaged and stored on at 15-minute intervals by the SCADA's integrated data-logger.

4.18.7 If several reference cells are installed due to various tilt / orientation angles of the PV modules, then the weighted average of the irradiation signals will be used for the Performance Ratio (PR) calculation. The weighted average will be determined by installing a Programmable Logic Controller (PLC) with analogue inputs and outputs (IO).

4.19 PLANT PERFORMANCE

4.19.1 The Performance Ratio (PR) is a measure of the PV plant's performance during the period that the plant is connected to the grid and producing energy (i.e., 100% availability).

4.19.2 The following technical parameters are required to be measured on site to perform and verify the performance tests for both, Performance Ratio Test and Plant Availability Test:

- AC Energy output at the Point of Generation Connection (PGC) [kWh].
- Global solar irradiation on plane of array [kWh/m²].
- Module temperature [°C].
- AC Energy output from each inverter [kWh].
- Ambient air temperature [°C].

The first two technical parameters (major parameters) mentioned above are used directly to verify the performance of the Plant. The later three parameters are used as back up to verify consistency of measurement of major parameters. These parameters are to be sampled instantaneously, averaged, and stored in a 15-minute interval. The logged data is to be checked for consistency and validity and must be found free from obvious anomalies or irregularities.

4.19.3 The plant Performance Ratio (PR) shall be evaluated by the SCADA system according to equations below,

$$[PR_{measured}]_{SAT} = \frac{[E_{prod}]_{SAT}}{[E_{PV}]_{SAT}}$$

Where:

$[PR_{measured}]_{SAT} =$ Average measured PR during the Site Acceptance Test period, expressed in %.

$[E_{prod}]_{SAT} =$ Sum of energy measured in energy meters installed at point of connection during the Site Acceptance Test period, expressed in kWh.

$[E_{PV}]_{SAT}$ = Theoretical energy that could have been produced by PV modules during the Site Acceptance Test period, expressed in kWh.

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

Where:

P_{Nom} = Nominal Peak Power of the PV Modules, sum of name plate power of modules installed in the plant, expressed in kWp.

$[Irr_{POA-measured}]_{SAT}$ = Average solar irradiation measured on the Plane of Array during the complete Site Acceptance Test period when the plant was available, expressed in kWh/m^2.

$[Irr_{STC}]$ = Solar irradiation at Standard Test Conditions (STC) condition, 1 kW/m^2 (constant).

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.

5.1.5 City of Cape Town, Technical Standard, EEB 705: Standard for the Interconnection of Embedded Generation

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.

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

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;

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

6. SITE DESCRIPTION

6.1 LOCATION

The Brackenfell site is located under the following address/coordinates:

- Address: 1 Eskom Road, Brackenfell, Cape Town, 7560, South Africa.
- GPS Coordinates: -33.8889903°S, 18.6849571°E (33°53'22.73"S, 18°41'6.14"E).

6.2 SOLAR PANELS

The engineering complex comprises of several buildings that house engineering practitioners who perform engineering work for the Eskom Distribution Division. There are 15 rows of carports that enable 522 parking bays with a rooftop area of 0.3412 ha. The estimated annual average Global

Horizontal Irradiation (GHI) is 1,932 kWh/m^2. This information is for the entire complex and is given as a loos reverence.

Figure 2 below shows the engineering complex with the Entrance, M-block and M-block carports identified. The carports are made of galvanized steel structures. The roof is a kliplock of 0,5 mm sheeting.

No building roof spaces will be used for PV installations.

Figure 2 - Brackenfell Engineering Complex

A structural analysis was performed to verify whether the existing carports' structure can withstand the assumed load without implementing any modifications. During this process the structures were checked under the following conditions:

- Weight of solar panels and support structures: 20 kg/m^2
- Panels fixed to the carport purlins
- Panels fixed flat on the carport roofs at an angle of 3 degrees

Different types of carport moment frames (Frames A and C – back to back carport marked as type 2, 3 and 4 in Figure 3) and frame B (front sided carport – marked as Type 1 and 5 in Figure 3) were analysed, refer to Appendix G: Carport Frames. The purlins were checked for the additional solar panel and support structure loads, only the downward wind pressure loads on the roof structure was considered as this would results in the most critical case.

The moment frames were found to be structurally sound to support the additional 20 kg/m^2. Purlins for frame A and frame C (spaced at 1 m and 1.1 m) can withstand the additional load. Wider spaced purlins (1.37 m) for frame B cannot withstand the additional weight and may not be used. Appendix H: Carport Structural Analysis Memo contains the explanation on the structural analysis for types 1 and 5. This information and the memo were obtained in 2017 and shall be confirmed by the contractor.

For this project only the M-block's parking structures will be considered. There are 2 rows of double-parking bays. These are type 2 as stated above. There are also 2 rows of single parking bays. The single parking bays are on both sides of the one entrance door to the building. These bays are closer to type 1 and may require some structural strengthening. As the previous structural analysis was done on a weight of 20 kg/m^2 and the offered solution may be less, it will have to be confirmed by the contactor if the additional structural strengthening is needed.

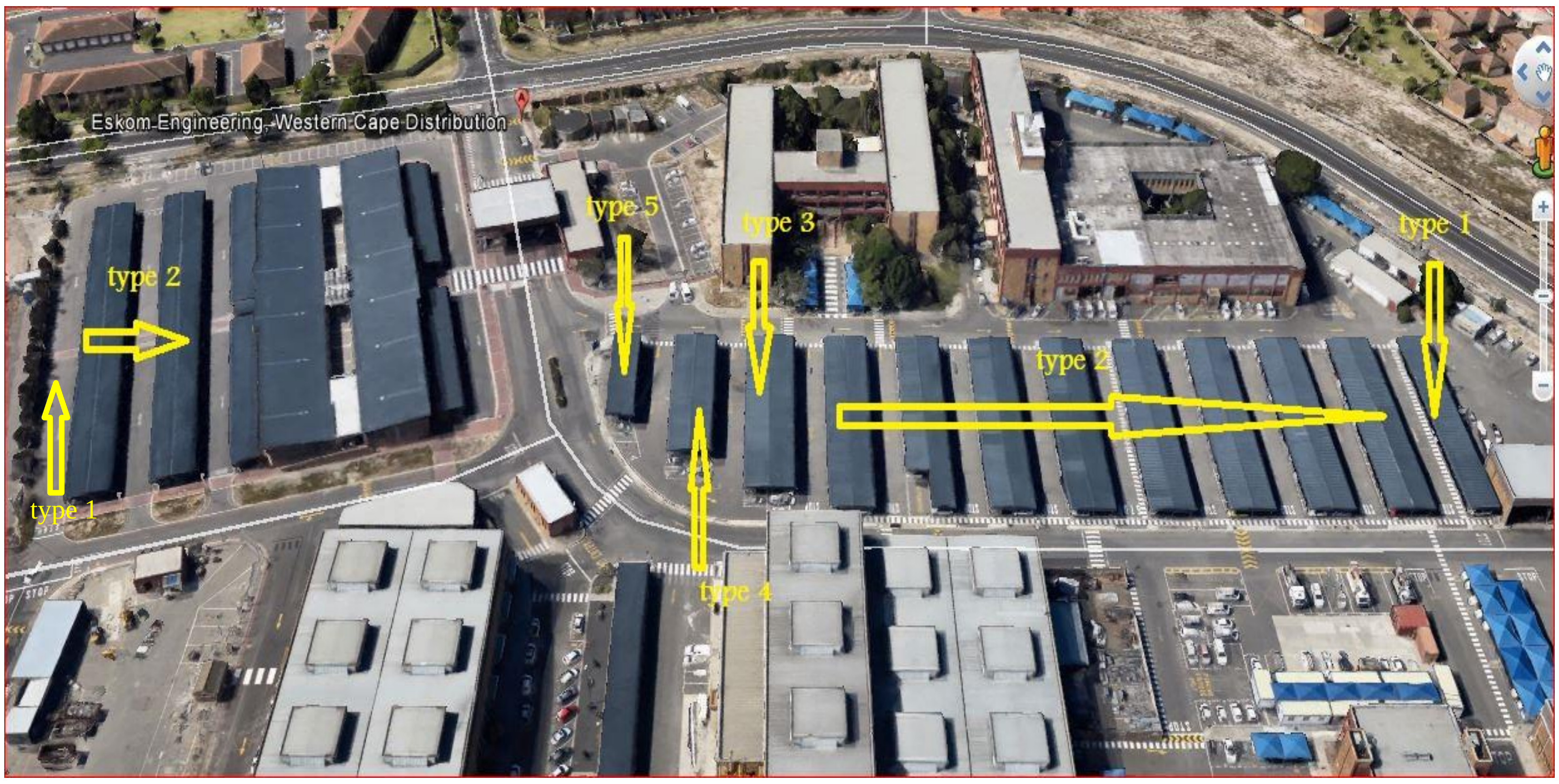

Figure 3 - Solar PV Site Carport Types

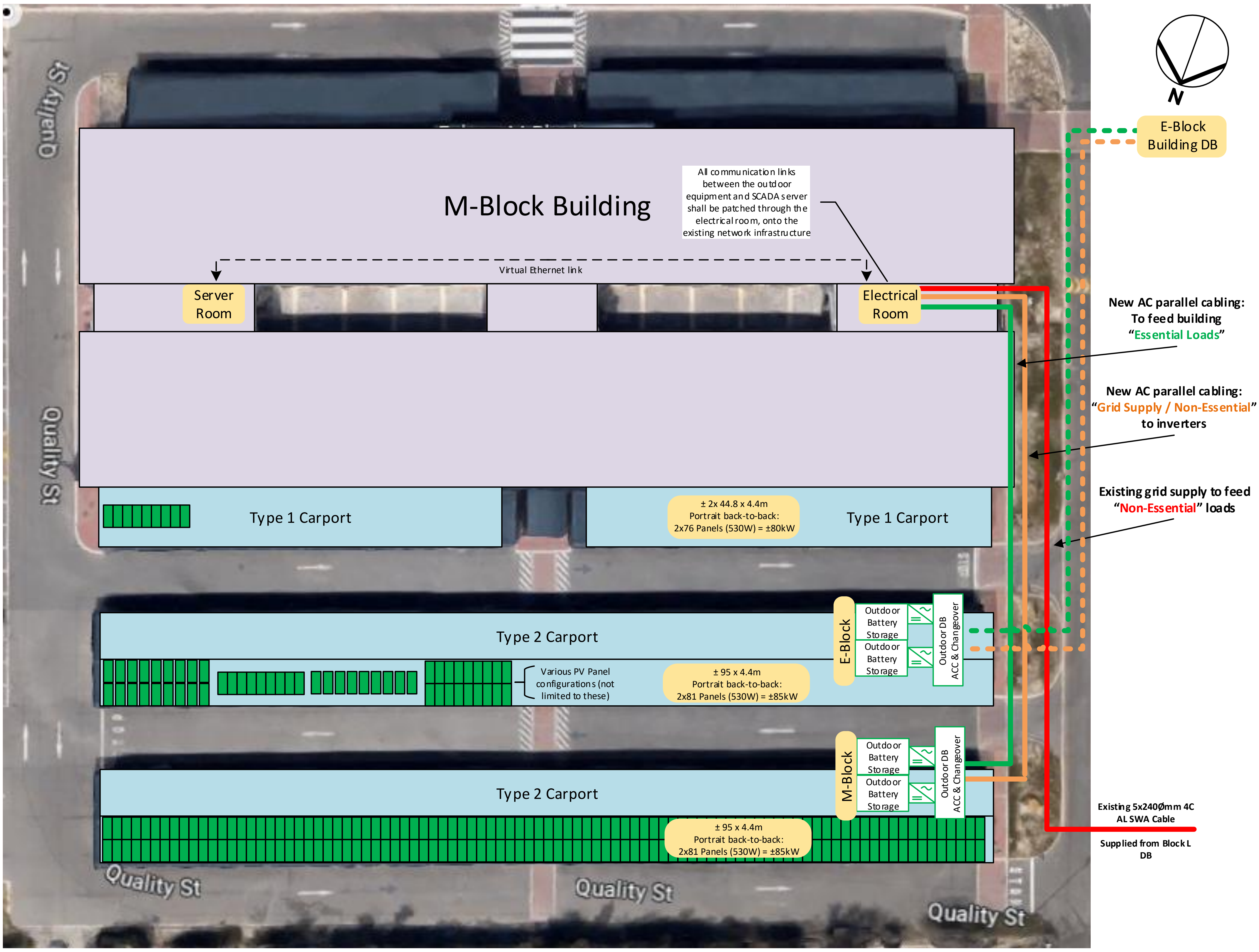

Figure 4 - Solar PV Site M-block Carport and proposed equipment layout and cabling

6.3 M-BLOCK ELECTRICAL CONNECTION

The M-Block building's main DB is situated on the ground floor as indicated in Figure 5.

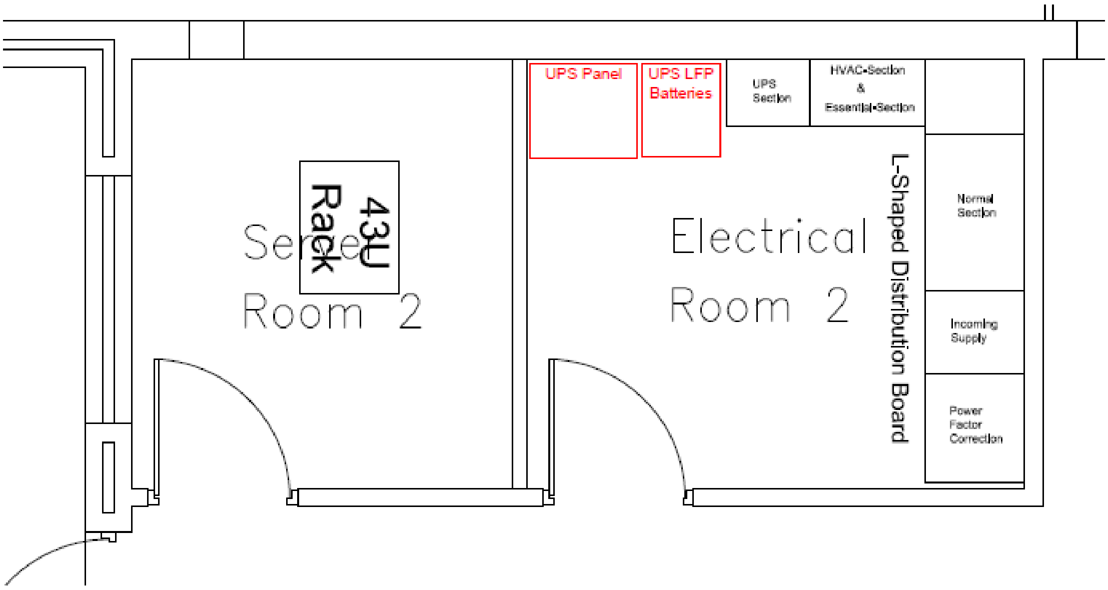

Figure 5 - M-Block building Main DB room

6.3.1 Physical space and layout:

Appendix F: M-Block building shows the entire ground floor of the building. There is space available in the Main Power and Lighting DB (MDB) for an additional supply MCB to the Outdoor cabinet. There may be space for a changeover, but this will have to be confirmed during the preliminary design.

6.3.2 Electrical connection:

Appendix B: M-Block Distribution Boards show the existing high-level electrical diagram of the Main Power and Lighting DB (MDB) (Figure 6), the proposed high-level electrical diagram of the Main Power and Lighting DB (MDB) (Figure 7) and the photo of the Main Power and Lighting DB (Figure 8).

This is a very new building and DB. The Orange is the normal power, the Red is generator power, and the Blue is UPS power. The generator is currently not installed. The main MCCB is an ABB SACE Emax X1B 10. The Breaker / Isolator to the future generator as well as the main switch to the generator portion of MDB is an ABB SACE Tmax, 400 A.

6.4 E-BLOCK ELECTRICAL CONNECTION

6.4.1 Physical space and layout:

This building is very old. There is a main distribution board that supplies 4 sub-distribution boards. The biggest sub-DB in turn supplies several smaller sub-DBs situated all over the building. Most of these DBs are old, flush mounted, shallow, and very full. There is some wall space next to the DBs but depending on the equipment ordered this may not be sufficient.

6.4.2 Electrical connection:

Appendix C: E-Block Distribution Boards show the existing high-level electrical diagram of the Main Power and Lighting DB (DB/EM) as well as sub-DB E1 (Figure 9), the proposed high-level electrical diagram of the Main Power and Lighting DB (DB/EM) as well as sub-DB E1 (Figure 10), the photo of the Main Power and Lighting DB (DB/EM) (Figure 11) and the photo of sub-DB E1 (Figure 12).

7. WARRANTIES

7.1 BASE AND RELATED WARRANTIES

7.1.1 All OEM guarantees and warrantees of equipment and material used within the system shall be transferred to Eskom.

7.1.2 The solution shall be offered with a 2-year base warranty where the Tenderer 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 Tenderer and honoured until their expiry.

7.1.4 A workmanship warranty of minimum of 5-years 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 overseas principal (OEM) shall be for the Contractor's expense.

7.1.8 The Tenderer shall clearly describe the conditions under which the offered warranties shall be honoured and as a minimum, the warranty agreements shall contain the intended and permissible use of the solution, covered after-sales maintenance support and repair work, in-line with the requirements here within.

7.1.9 The Contractor shall keep record of and manage all OEM product warranty agreements and claims on behalf of Eskom.

7.1.10 Where Eskom takes over some or all the O&M functions, the Contractor shall clearly state the O&M care regime that should be adhered to, to ensure that the warranties are not impacted. This shall be included in the maintenance documentation required as part this project.

7.2 PERFORMANCE WARRANTY

7.2.1 Performance warrantees 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.

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.

7.2.5 Under the **efficiency warranty**, the contractor shall guarantee that the solution is able to meet the required (e.g. sections 4.5 and 4.11) and tendered efficiencies.

7.2.6 The performance warranty parameters shall be logged by the Contractor and reported monthly (during the maintenance period). The report shall be concise and user friendly in indicating the actual performance against expected performance.

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 Preliminary design package for review. 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 BOM (Bill of Materials), to include detail of individual inverters, BESS / batteries, PV modules, integration equipment, SCADA, metering, major cable, structural works, etc.

8.1.4 BESS specifications, including the minimum guaranteed <u>usable</u> 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 power network diagram of the microgrid system.

8.1.7 Preliminary logic diagrams of the control systems.

8.1.8 Preliminary Communication network diagram, including a typical SCADA data/points list.

8.1.9 Basic project schedule, from contract signing to handover.

8.1.10 Details of how each of the *modes of operations* are achieved by the solution.

8.1.11 Detail of any risks and necessary mitigations that the tenderer has identified.

8.1.12 All other documentation as required by the tender.

8.1.13 List of spares & quantities that should be kept by Eskom (Tenderer to include failure calculations, based on MTBF of equivalent).

8.2 ENGINEERING & DESIGN

8.2.1 The Tenderer shall engineer and produce complete detailed designs, for all subsystems, and the overall solution as specified in the requirements.

8.2.2 All drawings shall be provided to Eskom in MicroStation compatible CAD format (dgn extension).

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

8.2.3 Where applicable, revised designs of all tendered documentation and drawings.

8.2.4 Final design drawings of all subsystems and the overall interconnected solution.

8.2.5 MV and / or LV switchgear arrangements for all PGCs.

8.2.6 Engineer's designs and specifications for any construction activities (e.g., foundations, PV mounts, etc.).

8.2.7 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 and SCADA system.

8.2.8 Detailed description of communication hardware for the microgrid as well as the communication mediums and devices used (wireless, fibre optics, media convertors, etc.).

8.2.9 Details of how the control system ties and operates with every control enabled device in the microgrid (PV, storage, switches, ATS, breakers, etc.).

8.2.10 Details on how both system-wide and device-level control algorithms work including associated diagrams and documentation.

8.2.11 Installation manuals, instruction manuals and operation guides for all equipment and subsystems.

8.2.12 All control and protective settings.

8.2.13 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.

8.2.14 Software documentation.

8.2.15 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.

8.2.16 Other project documentation that would reasonably be required to document the construction and operation of the microgrid.

8.2.17 As-built drawings and documentation upon final project acceptance, including that of all electrical and structural components installed and alterations made.

O&M plans (may in parts be combined if approved by Eskom):

8.2.18 Maintenance documentation in accordance with Eskom's Maintenance templates [1] and [2] shall be compiled. The maintenance documentation shall include a scheduled maintenance plan tailored to the system, detailing routine tasks, their frequencies, and responsible personnel.

8.2.19 A preventive maintenance checklist shall be provided to proactively maintain system components, including cleaning schedules, visual inspections, and component checks.

8.2.20 A list of recommended spare parts and consumables, including part numbers and sources for procurement, shall be provided for routine maintenance and replacements.

8.2.21 Instruction manuals for the operating of system.

8.2.22 O&M staffing plan and organization.

8.2.23 Annual operating & maintenance plan for the plant, indicating the proposed resources (manpower, material & machinery) that would be required.

8.2.24 Detailed Life of Plant Plan (LOPP) for the next 20 years that identifies all annual O&M costs, related to spares, maintenance (scheduled, un-scheduled, condition based) including major refurbishment, manpower, training, expected waste types and quantities, expected water usage requirements, and others.

8.3 EXECUTION

8.3.1 The Contractor shall supply, deliver, install, and commission all equipment required by the solution.

8.3.2 During such time all Eskom Life-Saving rules, as well as site rules shall be complied with.

8.3.3 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:

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

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

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

8.3.4 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 SITE ACCEPTANCE TESTING

8.4.1 The Contractor shall provide a full site acceptance testing (SAT) plan, for review, comment, and approval by the Employer.

8.4.2 Each component and subsystem shall be tested and proven to comply with the requirements.

8.4.3 The Employer shall witness all tests performed and sign each as such. Note that witnessing does not indicate compliance.

8.4.4 As a minimum (where installed) testing shall include the following. Test may be combined where feasible:

BESS:

8.4.4.1 System full capacity.

8.4.4.2 System round trip efficiency.

8.4.4.3 Sustained maximum power output (loads to be determined by the Employer).

8.4.4.4 Sustained charging current / power.

PV modules (individual or strings), including:

8.4.4.5 Open-circuit voltage.

8.4.4.6 Short-circuit current.

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

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

8.4.4.9 Insulation testing, where applicable.

Inverters:

8.4.4.10 Output voltage.

8.4.4.11 Output frequency.

8.4.4.12 Solar DC input to AC output efficiency under various loads.

SCADA and data logging:

8.4.4.13 Full functional test to satisfy all requirements.

Environmental instruments:

8.4.4.14 End to end test and calculation of performance data as required.

8.4.5 Eskom reserves the right to perform its own tests internally, through a 3rd parties, to verify that any requirement is met.

8.4.6 Once completed, the Contractor shall compile a SAT report for review and acceptance by the Employer.

8.5 TRAINING

8.5.1 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.

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

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

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

8.5.4.1 Installation Training

<u>Sessions: As and when needed by Eskom's staff, agreed upon between Eskom and the Contractor.</u>

The Contractor's project schedule shall be used by Eskom, with the contractor's input, to determine which activities will be aided or shadowed to/by Eskom staff. This will form part of a "hands-on" or practical intervention, mainly focussed on the physical installation scope. This includes:

- Installation of solar panel systems (mounting system, rails, PV modules, DC combiner boxes, cable, and cable routing systems, etc.).
- Installation of distribution boxes & enclosures, etc. (AC combiner boxes, DBs, breakers, isolators, changeover, etc.).
- Installation of inverters (mounting / securing, cabling, basic configuration/setup).
- Integration to existing building distribution boards.
- Electrical tests performed on each component to verify performance during installation.

8.5.4.2 Generic Design, System Overview, and Hardware Training

<u>Sessions: 2 Sessions with up to 10 attendees each.</u>

Comprehensive system-wide training on all hardware components including the BESS, inverters, solar modules, cabling, protective, control and monitoring devices / systems, communication and the SCADA 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 <u>this design</u>, 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.

8.5.4.3 SCADA System and Network Administration Training

Sessions: 1 Session with up to 10 attendees

- 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.
- Detail of the API supported along with usage examples.
- Typical failure modes (what can be expected if the system fails) and backup and recovery options.
- Detailed training on the SCADA features and functions, including how to configure the existing system and add new/future systems.
- User management.
- Creation of the HMI's.

8.5.4.4 Operation and Maintenance training

Sessions: 1 Session with up to 10 attendees

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.

- The complete system's full life-cycle maintenance regimen.
- Typical equipment failure modes (how they fail) and replace / recovery options shall be included. Detail what equipment have higher failure rates.
- Preventative maintenance tasks.
- 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.

8.6 SPARES

8.6.1 In addition to the spares list required in section 8.1.13, the following spares shall be supplied by the Contractor to Eskom:

8.6.1.1 5x Solar panel, per type/size installed,

8.6.1.2 2x Battery fuses (if fuses are utilised),

8.6.1.3 10%+1 of the installed PV fuses (if fuses are utilised),

8.6.1.4 10%+1 of the installed solar SPDs (DC).

9. OPERATIONS AND MAINTENANCE PERIOD

9.1 PREVENTATIVE/SCHEDULED MAINTENANCE

9.1.1 A scheduled maintenance and care period of 1 year will form part of the contract, commencing 1 month after commercial operation, with a 1-month period for 12 total months. I.e. maintenance intervals shall be set 1 months apart.

9.1.2 The scheduled O&M scope includes, preventative & predictive maintenance, operations of the BESS, and managing system performance in line with the Performance Warrantee conditions (where applicable).

9.1.3 The schedule maintenance period excludes corrective or breakdown maintenance, unless covered by the guarantees and warrantees provided.

9.1.4 Scheduled maintenance dates and the replacement of any parts will be performed after agreement with the *Eskom* representative who will be present during the corrective interventions.

9.1.5 All scheduled maintenance activities shall include the cost of labour, parts, consumables and cost of travel and subsistence expense.

9.1.6 The maintenance contractor shall be accredited by the OEM or duly delegated representative.

9.1.7 Eskom rules shall always be adhered to when performing any activities at site.

9.1.8 All scheduled maintenance activities on equipment shall be executed as per the supplied OEM maintenance base and in line with the OEM recommendations.

9.1.9 Replaced components shall not degrade the overall system in any way.

9.1.10 Maintenance parts utilised shall be fully compatible with the equipment supplied and correct performance and appropriate operation shall be guaranteed.

9.1.11 By virtue of the Department of Labour (DOL) mandate to South African Qualifications Certification Committee (SAQCC), any person performing work on Fire Detection Systems, Gaseous Fire Protection and Fire Extinguishers needs to be registered with SAQCC at the appropriate level as dictated by SAQCC e.g., designer, installer, commissioner, or serviceman.

9.2 CORRECTIVE MAINTENANCE

9.2.1 The *Contractor* shall provide for any corrective maintenance that fall within the warranties and guarantees provided.

9.2.2 The response time to attend to such failures shall be as soon as possible and 3 days at most.

9.2.3 Each failure intervention shall principally be resolved within 10 consecutive working days.

9.2.4 Corrective maintenance covered by warranties and guarantees shall be performed at no cost to Eskom.

9.2.5 The replacement of any parts will be performed after agreement with the *Eskom* representative who will be present during the corrective interventions.

9.2.6 The parts supplied must be fully compatible with the equipment and the correct performance and appropriate operation shall be guaranteed.

9.3 REPORTS

9.3.1 At the end of each intervention, both for the scheduled and corrective maintenance, a Technical Report will be produced, signed by the contractor, and countersigned by the *Eskom* representative. This report will indicate the work performed, the time spent and include a detailed account of the defects found and of any parts replaced.

9.3.2 At the end of the scheduled maintenance period a Final Progress Report will be produced. This report will consist of:

- copies of all countersigned technical report/s,
- detailed analysis of the current state of system performance,
- list any amendments required to documents previously submitted (due to works carried out during the maintenance period), especially to any maintenance requirements (imminent or future).

9.3.3 The maintenance data and information shall be in the prescribed Eskom format or captured in the relevant Eskom operational technology (OT) maintenance management systems.

10. REVISIONS

Date	Rev.	Compiler	Remarks
October 2023	1	TJ Hyman & C Van Schalkwyk	First issue

11. DEVELOPMENT TEAM

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

- Tertius Hyman
- Christine van Schalkwyk

Extracts were used from the 2017 report titled Brackenfell Carport Solar PV Concept Design Report (399-SPV-MBBZ26-RP0000-2), with the following contributors:

- Miranda Skaka
- Rosemary Mathebula
- Andries van der Walt
- Rajiv Beharie

APPENDIX A: METERING BILL OF MATERIALS

WESTERN CAPE OPERATING UNIT PROJECT ENGINEERING - HV SUBSTATION BOM				
CONTROL PLANT				
	METERING			
QTY	**SAP**	**REFERENCE**	**Rev**	**DESCRIPTION**
	>100kVA Installations			
1	0615099			METER ZMG 1&5A 3PH CL0.5 RS232/RS485 (ZMG405CR4.041B.37)
3	BUY-OUT			Current Transformers: ITT or Current Electric. 200/5A, 300/5A, 500/5A, 800/5A, 1600/5A
1	0661600			SMARTGRID MODEM:BASIC CELLULAR REMOVABLE SIM;3G; SG101
1	0606351		**5**	Webb ESKANT Antenna

APPENDIX B: M-BLOCK DISTRIBUTION BOARDS

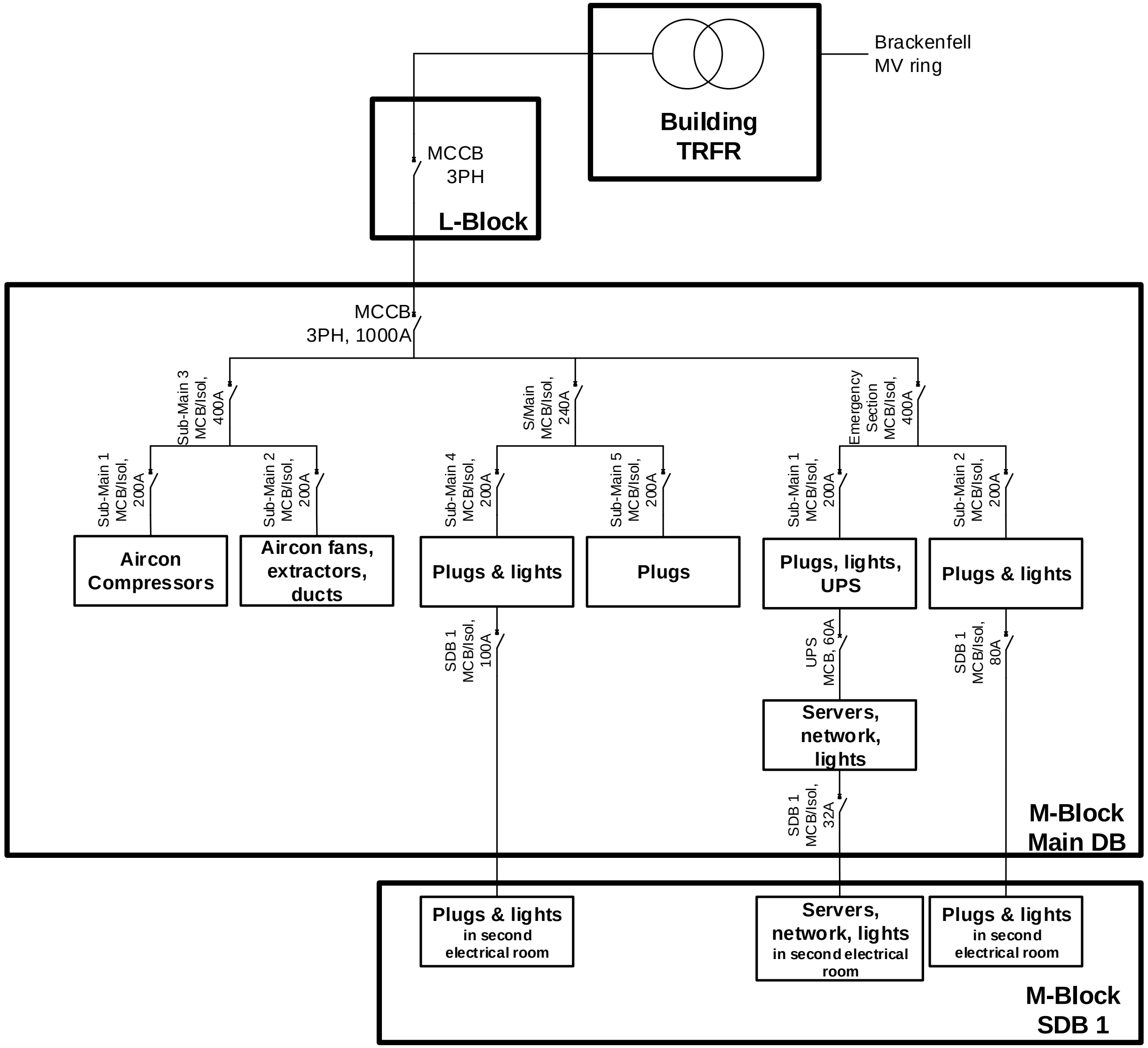

Figure 6 – Existing M-Block DBs

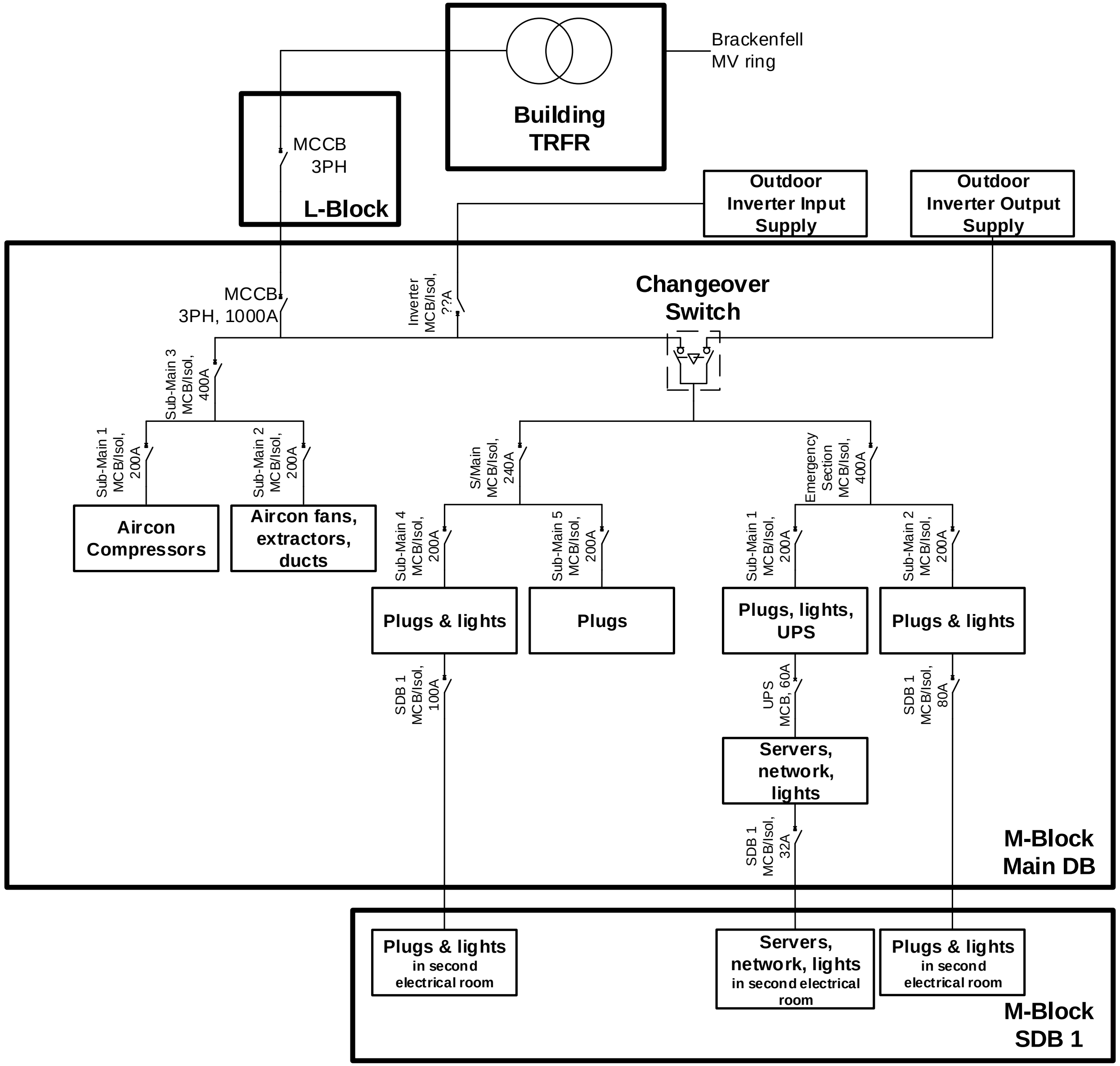

Figure 7 – Proposed M-Block DBs

Figure 8 – M-Block building Main Power and Lighting DB (MDB)

APPENDIX C: E-BLOCK DISTRIBUTION BOARDS

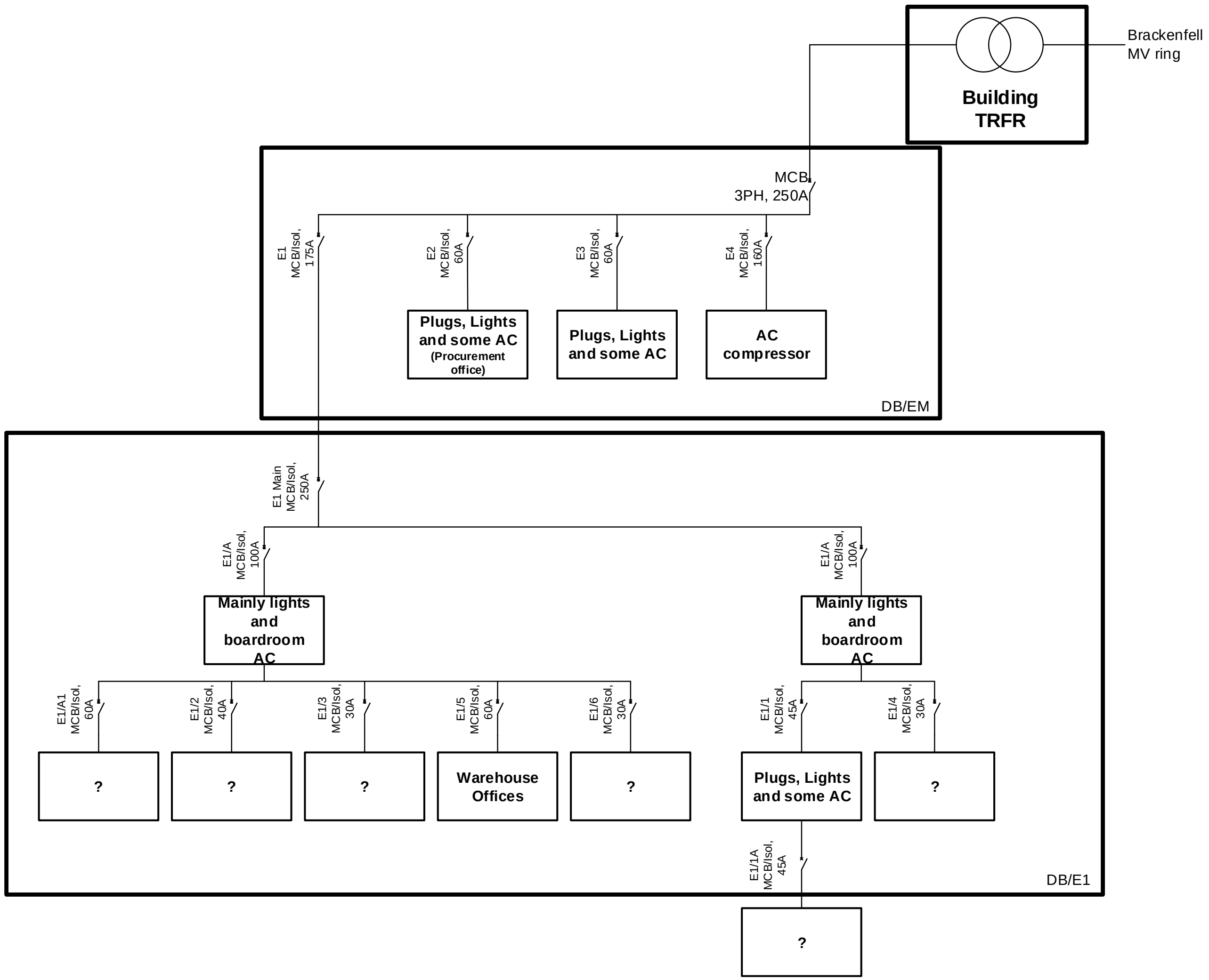

Figure 9 – Existing E-Block DBs

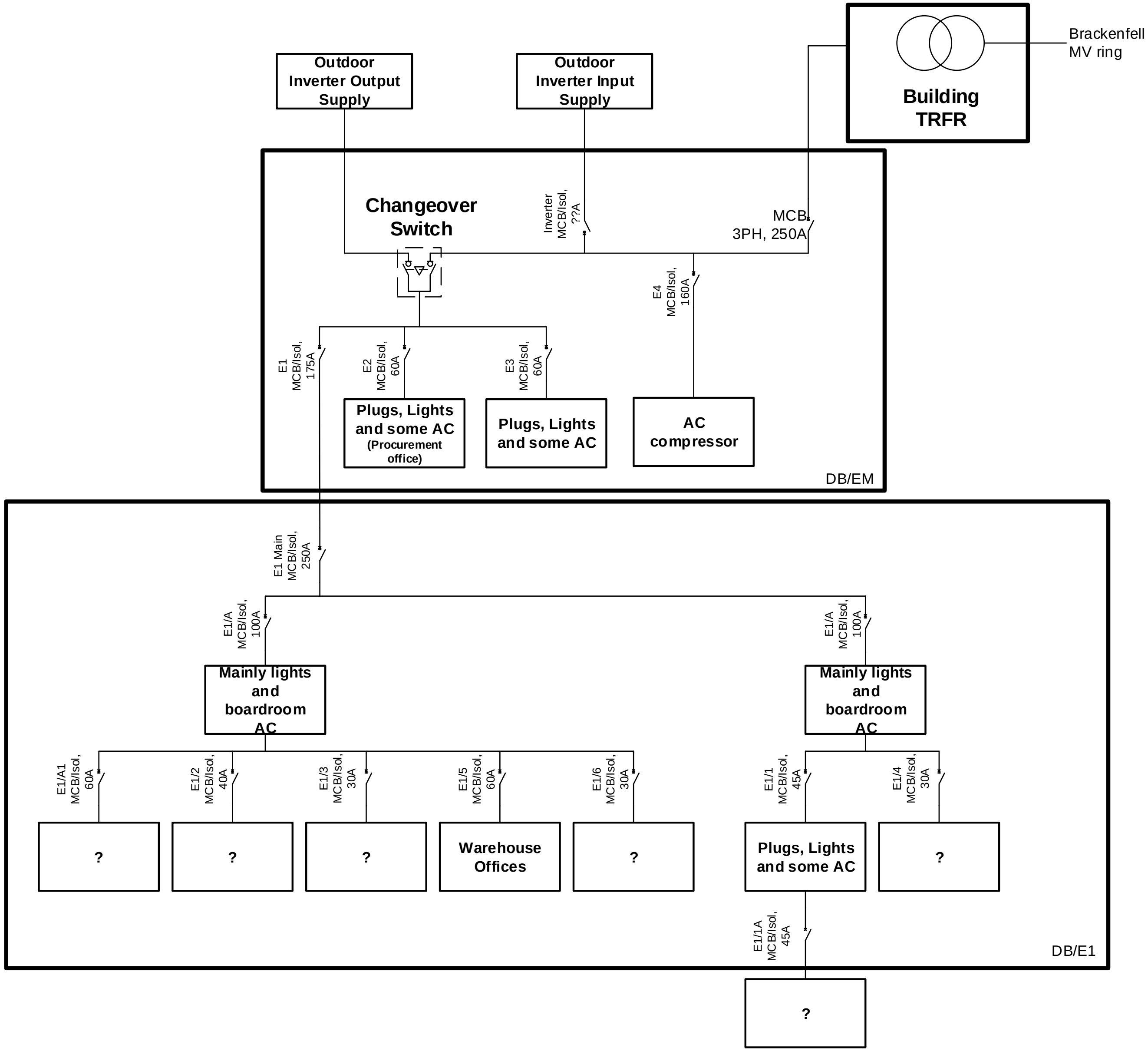

Figure 10 – Proposed E-Block DBs

Figure 11 – DB/EM – Main DB in E-block

Figure 12 – Sub-DB E1

APPENDIX D: ENGINEERING COMPLEX MV SINGLE LINE DIAGRAM (SLD)

See attachment.

APPENDIX E: BRACKENFELL COMPLEX MV AND LV CABLING

See attachment.

APPENDIX F: M-BLOCK BUILDING

See attachment.

APPENDIX G: CARPORT FRAMES

See attachment.

APPENDIX H: CARPORT STRUCTURAL ANALYSIS MEMO

See attachment.