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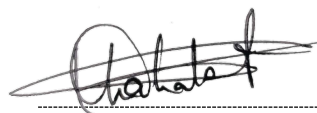
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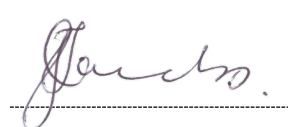
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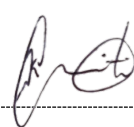
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Content

	Page
Executive Summary.....	4
1. Introduction.....	5
2. Supporting clauses	5
2.1 Scope	5
2.1.1 Purpose.....	5
2.1.2 Applicability	5
2.2 Normative/informative references	5
2.2.1 Normative.....	5
2.2.2 Informative	6
2.3 Definitions.....	8
2.4 Abbreviations.....	8
2.5 Roles and responsibilities	9
2.6 Process for monitoring	9
2.7 Related/supporting documents	10
3. Scope of Work	10
3.1 Objective	10
3.2 Site Specific Details.....	10
3.2.1 Site Location	10
3.2.2 NMC and Dx IT Data Centre Standby Systems (UPS).....	11
3.2.3 The System's Topologies and Parameters	12
3.2.4 Battery Rooms Condition	13
3.2.5 Gap Assessment.....	18
3.3 High Level Scope of Work.....	19
3.4 Detailed Scope of Work.....	20
3.4.1 Overall System Topology and Functional Requirements	20
3.4.2 UPS Specification	23
3.4.3 Utility AC Power Supply Specification requirements	24
3.4.4 Battery Specification	24
3.4.5 NMC Charger requirements.....	26
3.4.6 Standby Generator requirements	26
3.4.7 UPS Distribution Boards and Cable Work	27
3.4.8 Drawings	28
3.4.9 General	28
3.5 Contractor.....	29
3.5.1 Execution	29
3.5.2 Responsibility Assignment Matrix (RACI)	30
3.5.3 Key Personnel Competency Requirements.....	31
3.5.4 Site Acceptance Testing	32
3.5.5 Training	33
3.5.6 Spares Provision	36
3.5.7 Warranties.....	36
3.5.8 Operation and Maintenance Period	37
3.6 Contractor Responsibilities	37
3.6.1 Reticulation Assessment.....	38

CONTROLLED DISCLOSURE

3.6.2	Engineering Design and System Specification	38
3.6.3	Documentation and Coordination	38
3.6.4	Compliance and Safety	39
4.	Acceptance	39
5.	Revisions	39
6.	Development team	39
7.	Acknowledgements	39
	Appendix A – NMC	40
	Appendix B – IT Data Centre	50

Figures

Figure 1:	Google Maps Screenshot of the Eskom Simmerpan aerial view	11
Figure 2:	NMC UPS system single line diagram	13
Figure 3:	Dx IT Data Centre UPS system single line diagram (Single UPS System)	13
Figure 4:	The existing NMC battery room layout	14
Figure 5:	The existing Dx IT Data Centre battery, UPS, and server room layout	16
Figure 6:	Emergency Standby Power Systems single line block diagram for a Priority 1 site	20
Figure 7:	Standby Power System Replacement Project Phases	30

Tables

Table 1:	The existing standby system at Simmerpan NMC	11
Table 2:	The existing standby system at Simmerpan Dx IT Data Centre	12
Table 3:	The existing battery room specification (NMC)	14
Table 4:	NMC Battery Room General Conditions Based on the Standard	14
Table 5:	NMC Battery Room Civil Works Conditions	15
Table 6:	NMC Battery Room Electrical Conditions	16
Table 7:	Dx IT Data Centre Battery Room General Conditions Based on the Standard	17
Table 8:	Dx IT Data Centre Battery Room Civil Works Conditions	17
Table 9:	Dx IT Data Centre Battery Room Electrical Conditions	18
Table 10:	NMC and IT Data Centre minimum required equipment rating.	19
Table 11:	Required topologies and standby times for Priority 1 sites / facilities.	21
Table 12:	Project RACI	30

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Executive Summary

This technical document forms part of a national initiative to improve the resilience, reliability, and availability of standby power systems within Distribution Network Management Centres and associated critical information technology facilities. The scope of this document focuses on the Simmerpan Network Management Centre and the Dx IT Data Centre, which support critical SCADA, operational control, server, monitoring, and communication systems requiring continuous and secure power supply.

The existing standby power infrastructure has been assessed and found to require replacement and enhancement to address limitations in redundancy, maintainability, system robustness, and long-term operational reliability. Given the critical nature of the supported loads, the proposed standby power solution must provide high availability, improved fault tolerance, adequate autonomy, and compliance with applicable Eskom and recognised international standards.

Accordingly, this document defines the user requirement specification for the replacement of the existing standby power systems. It sets out the functional, technical, performance, reliability, maintainability, and compliance requirements necessary to ensure that the new standby power infrastructure is fit for purpose and capable of supporting continuous operation of critical facilities under normal, abnormal, and emergency supply conditions.

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1. Introduction

As part of a comprehensive national initiative aimed at fortifying the resilience of standby power systems within Distribution Network Management Centres (NMCs), this technical report delves into the specific case of the Simmerpan NMC. Given the critical nature of uninterrupted power supply in facilitating smooth operations and ensuring the reliability of the SCADA system and its associated departments, a detailed assessment of the existing Uninterruptible Power Supply (UPS) infrastructure is essential.

2. Supporting clauses

2.1 Scope

2.1.1 Purpose

This document defines the user specific requirements for the replacement of the standby power system at the Simmerpan NMC and IT Data Centre. It outlines the scope and processes to be followed to ensure a structured, compliant, and fit-for-purpose implementation of the new standby power system for both sites.

2.1.2 Applicability

This document shall apply throughout to the Simmerpan NMC and IT Data Centre Standby Power Systems.

2.2 Normative/informative references

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

2.2.1 Normative

- [1] ISO 9001, Quality Management Systems.
- [2] IEC 62040-1, Uninterruptible power systems (UPS) – Part 1: Safety requirements
- [3] IEC 62040-2, Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements.
- [4] IEC 62040-3, Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements.
- [5] 240-118870219, Standby Power Systems Topology and Autonomy for Eskom Sites.
- [6] SANS 10142-1, The wiring of Premises – Part 1: Low voltage installation.
- [7] SANS 1091, National colour standard.
- [8] SANS 60529, Degrees of protection provided by enclosures (IP code).
- [9] 240-62772907, Specification for stationary diesel generator system
- [10] 240-171000447, Maintenance standard for standby generators for distribution

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- [11] 240-171000445, Maintenance of diesel generators for distribution (Manual)
- [12] RCC Generator Replacement project
- [13] IEC 62103, Electronic equipment for use in power installations.
- [14] 240-53114248, Thyristor and Switch Mode Chargers, AC/DC to DC/AC Converters and Inverter / Uninterruptible Power Supplies Standard.
- [15] 240-56177186, Battery Room Standard.
- [16] 240-170000103, Lithium Iron Phosphate Batteries Standard.
- [17] 240-56360034, Stationary Vented Lead Acid Batteries Standard.
- [18] 240-51999453, Standard Specification for Valve-Regulated Lead-Acid Cells.
- [19] 240-56360086, Stationary Vented Nickel Cadmium Batteries Standard.
- [20] 240-56176113, Classification of Battery Rooms Work Instruction.
- [21] 240-56536505, Hazardous Locations Standard.
- [22] 240-54937450, Fire Protection and Life Safety Standard
- [23] 240-56737448, Fire Detection and Life Safety Design Standard.
- [24] 240-89797258, The Safe Handling, Transportation and Disposal of Cells, Batteries and Electrolyte.
- [25] SANS 10400-A, The Application of the National Building Regulation Part A: General principles and requirements.
- [26] SANS 10400-T, The Application of the National Building Regulations Part T: Fire protection.
- [27] SANS 60086-4, Safety of lithium batteries.

2.2.2 Informative

- [1] IEC 60898-1, Electrical accessories – Circuit breakers for overcurrent protection for household and similar installations Part 1: Circuit-breakers for AC operation.
- [2] IEC 60898-2, Electrical accessories – Circuit breakers for overcurrent protection for household and similar installations Part 2: Circuit-breakers for AC and DC operation.
- [3] IEC 60364-4-41 Low-voltage plants installation. Part 4-41 - Protection for safety – protection against shock.
- [4] SANS 164-0, Plug and socket-outlet systems for household and similar purposes for use in South Africa Part 0: General and safety requirements.
- [5] SANS 164-1, Plug and socket-outlet systems for household and similar purposes for use in South Africa Part 1: Conventional system, 16A, 250VAC.
- [6] SANS 767-1, Earth leakage protection units Part 1: Fixed earth leakage protection circuit breakers.
- [7] SANS 60309-1, Plugs, socket-outlets and couplers for industrial purposes: Parts 1, 2 and 4.
- [8] SANS 60947-4-1, Low-voltage switchgear and control gear. Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters.
- [9] SANS 60947-1, Low-voltage switchgear and control gear – Part 1: General rules.

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- [10] SANS 60947-2, Low-voltage switchgear and control gear – Part 2: Circuit-breakers.
- [11] SANS 61643-1, Low voltage protective devices - Part1: Surge protective devices connected to low voltage power distribution systems – Requirements and tests.
- [12] 240-56063805, LV Power and Control Cable with Rated Voltage Standard 600/1000V
- [13] 240-56356396, Earthing and Lightning Protection Standard.
- [14] IEC 60364-4-41, Low-voltage plants installation. Part 4-41 - Protection for safety – protection against shock.
- [15] SANS 10292, Earthing of low-voltage (LV) distribution systems.
- [16] SANS 10199, The design and installation of earth electrodes.
- [17] SANS 61312-3, Protection against lightning electromagnetic impulse Part 3: Requirements of surge protective devices (SPDs).
- [18] SANS 10313 - Protection against lightning - Physical damage to structures and life hazard.
- [19] SANS 10200, Neutral earthing medium voltage industrial power systems.
- [20] NRS 039 Part 1 and Part 2, Surge arresters for use in distribution systems.
- [21] IEC 61009, Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBO's).
- [22] 240-56227589, List of electronic devices to be used on Eskom Distribution Site standard.
- [23] 240-56359083, Metering and Measurement Systems for Distribution Sites in Generation.
- [24] IEC 61850-7, Communication networks and systems for power utility automation - Part 7-
- [25] Basic communication structure – Distributed energy resources logical nodes.
- [26] IEC 62381, Factory acceptance test (FAT), site acceptance test (SAT), and site integration test (SIT).
- [27] IEC 62382, Electrical and Instrumentation loop check activities.
- [28] IEC 62337, Commissioning of electrical, instrumentation & control systems.
- [29] EIA/TIA 568, Standard for structured cabling.
- [30] EIA/TIA 569, Standard for communication pathways and spaces.
- [31] EIA/TIA 607, Standard for grounding and bonding of communication cabling.
- [32] TIA/EIA 485, Electrical Characteristics of Generators and Receivers for Use in Balance Digital Multipoint Systems.
- [33] TSB-89-A, Application Guidelines for TIA/EIA-485-A.
- [34] SANS 10340-1, Installation of telecommunication cable's part 1: Fibre optic cables in buildings.
- [35] SANS 60794-1-1, Optical fibre cables - Part 1-1: Generic specification – General.
- [36] SANS 60794-1-2, Optical fibre cables - Part 1-2: Generic specification - Basic optical cable test procedures.
- [37] SANS 61312, Protection against lightning electromagnetic impulse.
- [38] SABS 1411 Parts 2-6, Materials of Insulated Electric Cables and Flexible Cords.

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- [39] SANS 60947-7-1 and 60947-7-2, The terminal blocks for the junction box terminations.
- [40] SANS 60429, Degree of protections provided by enclosures (IP).
- [41] 240-56355754, Field Instrument Installation Standard, section 3.
- [42] 240-56355815, Field Instrument Installation Standard Junction Boxes and Cable Termination.
- [43] 240-56355541, Control System Computer Equipment Habitat Requirements Guideline.
- [44] 32-373 Information Security, IT/OT and Third-Party Remote Access Standard.
- [45] 240-55410927, Cyber Standard for Operational Technology.
- [46] 240-79669677, DMZ designs for Operational Technology.
- [47] 240-64038621, Remote Device Communication Standard for Data Retrieval and Remote Access.
- [48] 240-122024110, Environmental Alarm System Building Management System Standard for DMS
- [49] Southern African Steel Construction Handbook (Red Book):
- [50] SANS 10160, Basis of structural design and actions for buildings and industrial standards.
- [51] SANS 10162-1, The structural use of steel Part 1: Limit states design of hot-rolled steelwork.
- [52] SANS121:2011 Ed2, Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods.
- [53] SANS 2001 – CS1 Ed.1.01, Construction works Part CS1 – Structural steel works.
- [54] SANS 1921-3 Ed.1, Construction and Management requirements for works contracts – Part 3 Structural steel works.
- [55] SANS 1200H Ed3, Standard specification for Civil Engineering construction – Structural steel work installation.
- [56] SANS 1200HC, Standardized specification for civil engineering construction Section HC: Corrosion protection of structural steelwork.
- [57] 240- 56364535, Architectural technical specification for structures and other buildings.
- [58] 240- 56364545, Structural design and engineering standard.
- [59] IEC 60947-6-1, Low-voltage switchgear and control gear - Multiple function equipment – Transfer switching equipment.
- [60] IEC 60947-3, Low-voltage switchgear and control gear – switches, disconnectors, switch disconnectors, and fuse-combination units.

2.3 Definitions

None

2.4 Abbreviations

Abbreviation	Description
AC	Alternating Current

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ATS	Automatic Transfer Switch
BMS	Building Management System
CoC	Certificate of Compliance
DC	Direct Current
DoD	Depth of Discharge
Dx	Distribution
FAT	Factory Acceptance Test
I	Current
LiFePO4/LFP	Lithium Iron Phosphate
NMC	Network Management Centre
P	Active Power
PF	Power Factor
PMS	Power Management System
S	Apparent Power
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SOC	State of Charge
UPS	Uninterruptible Power Supply
URS	User Requirement Specification
V	Voltage

2.5 Roles and responsibilities

- a) The PTM&C CoE of the Distribution Technology & Engineering Department will provide technical support from a national perspective for the execution of the project.
- b) The Project Manager and/or Distribution Real Estate Manager must ensure that representatives from Network Engineering Design (NED) and Control Plant Maintenance (CPM) are included as members of the project team.
- c) Their involvement is required to ensure appropriate lifecycle support for the assets, specifically:
 - 1) NED representatives will provide the necessary technical support; and
 - 2) The Plant Department shall ensure that assets created under this project is captured in the appropriate asset management system (e.g. Maximo) and the requisite job plans and works orders are created and issued according to the applicable Maintenance Engineering Standard.
 - 3) CPM representatives will provide operating and maintenance support during the operational and maintenance phase of the assets.

2.6 Process for monitoring

The requirements shall be monitored through design reviews, approved hold points, factory acceptance testing, site acceptance testing, commissioning records, performance verification, defect close-out and final handover acceptance.

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2.7 Related/supporting documents

The previous Regional Control Centre Generator Replacement project scope is included in this project.

3. Scope of Work

3.1 Objective

- a) The primary goal of the project is to guarantee that the standby power systems at the Distribution NMC and Dx IT Data Centre adhere to the minimum stipulations outlined in 240-118870219, focusing on the standby power systems' topology and autonomy for Eskom sites. This project will focus on the NMC and Dx IT Data Centre sites/buildings, and it is to be completed simultaneously. These buildings will have the same system topologies, technical specs (unless stated otherwise), scopes etc.
- b) Secondary objectives encompass the following:
 - 1) Ensuring that the NMC building's standby and uninterruptible power supply systems are adequately designed, configured, and reticulated to provide reliable and continuous supply to critical loads, including SCADA equipment, servers, telecommunications equipment, Resource Management Centre operational loads, and other essential building services.
 - 2) Implementing measures, such as capacity building and resource allocation for maintenance, to ensure the sustainable lifecycle management of these assets.

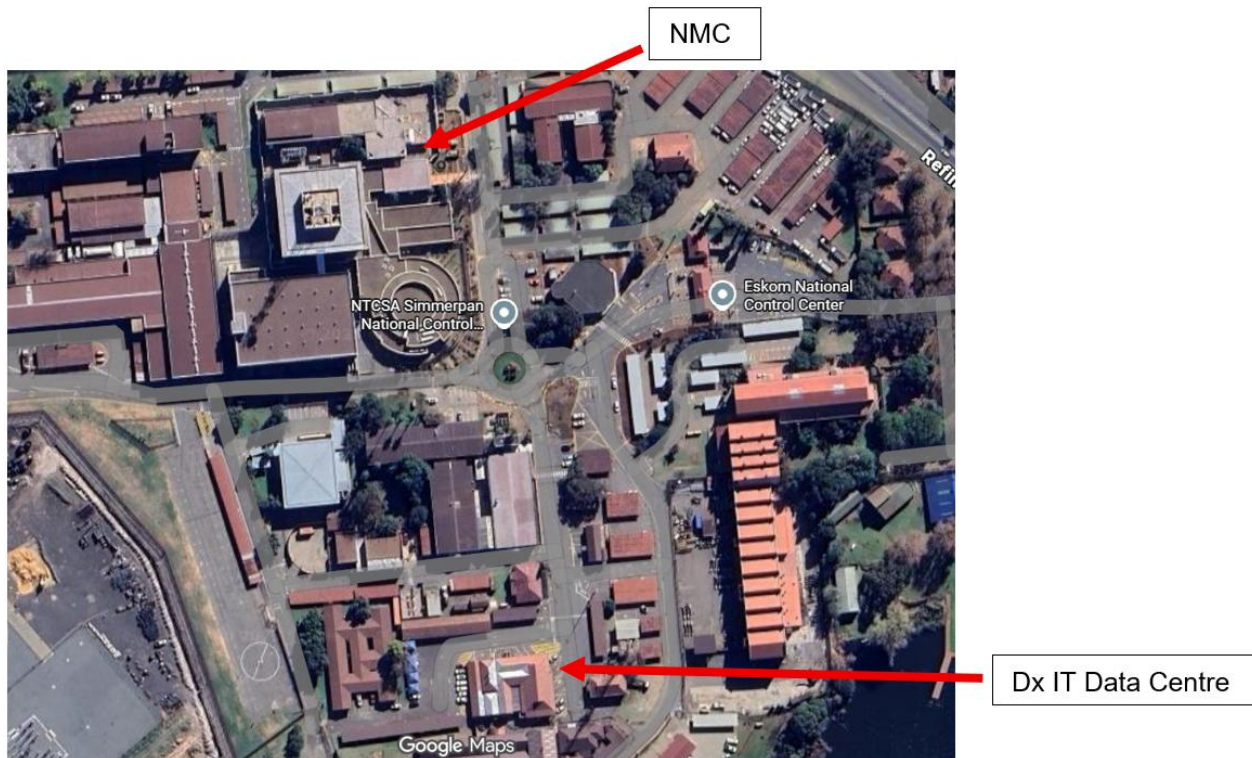
3.2 Site Specific Details

3.2.1 Site Location

The site's physical address is 102 Refinery Road, for both the NMC and Dx IT Data Centre. NMC's GPS coordinates are 26°13'28.7"S, 28°09'32.4"E and Dx IT Data Centre GPS coordinates are 26°13'36.3"S, 28°09'34.7"E.

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Figure 1: Google Maps Screenshot of the Eskom Simmerpan aerial view



3.2.2 NMC and Dx IT Data Centre Standby Systems (UPS)

The project comprises of two similar systems which are dual redundant UPS systems at the NMC and Dx IT Data Centre buildings, located at Eskom Simmerpan offices.

Table 1 and Table 2 below show the details of the existing standby power system at Simmerpan NMC and in the Dx IT Data Centre, respectively.

Table 1: The existing standby system at Simmerpan NMC

System	Essential Loads	Equipment	Configuration	Make / Model	Ratings	Phases In/Out	Installation Date
UPS 1 ¹⁾	NMC	UPS	Single	MGE Galaxy PW	80kVA	3/3	unknown
		Battery Bank ²⁾	30//30 bank	Hoppecke / VRXFT12-170	170Ah (x2), 12V (x30)	1/1	2023
UPS 2 ¹⁾	NMC	UPS	Single	MGE Galaxy PW	80kVA	3/3	unknown
		Battery Bank ²⁾	30//30 bank	Hoppecke / VRXFT12-170	170Ah (x2), 12V (x30)	1/1	2023
Standby Generators ³⁾		1	Single	Newage Stamford AC Generator C534B	250kVA 380/220V	0/3	unknown

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System	Essential Loads	Equipment	Configuration	Make / Model	Ratings	Phases In/Out	Installation Date
		2	Single	Newage Stamford AC Generator C20B	31.25kVA 380/220V	0/3	unknown
Notes: 1) Configured as a dual, redundant UPS System with combined input and output AC supplies. 2) The Hoppecke batteries are valve regulated, lead acid (VRLA) 3) The generators are installed indoors.							

Table 2: The existing standby system at Simmerpan Dx IT Data Centre

System	Essential Loads	Equipment	Configuration	Make / Model	Rating	Phases In / Out	Installation Date
UPS	Servers	UPS	Single	Liebert NXa 80 kVA (Emerson Power Network)	80kVA	3/3	unknown
		Battery Bank	40 batteries blocks	Hoppecke VRLA/VRXFT12 -170	170Ah 12V (x40)	1/1	2023
Generator 1)	HVAC, Fire System	Generator	Diesel Generator	International	200kV A	0/3	2004
Note: This is an outdoor unit							

3.2.3 The System's Topologies and Parameters

The single line diagrams of the existing UPS topologies for the NMC and Dx IT Data Centre are indicated Figure 2 and Figure 3, respectively.

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Figure 2: NMC UPS system single line diagram

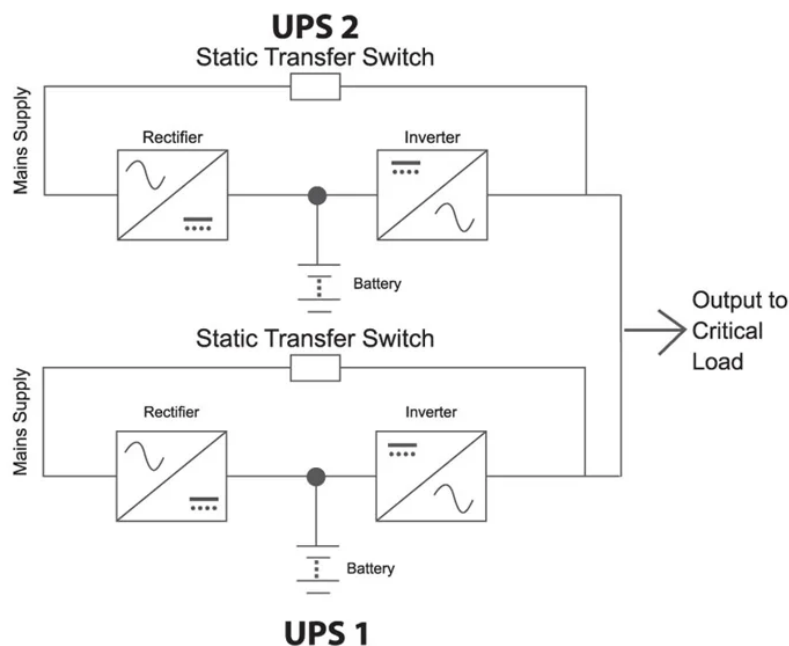
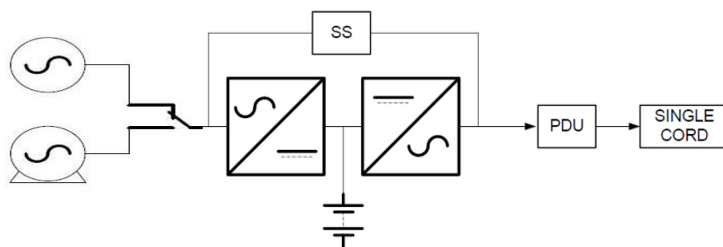


Figure 3: Dx IT Data Centre UPS system single line diagram (Single UPS System)



3.2.4 Battery Rooms Condition

- The batteries at both the NMC and Dx IT Data Centre have just been recently replaced (2023) and are visually in a good state. Both facilities are equipped with the Hoppecke grid | power VR X-FT 12-170, valve-regulated lead-acid (VRLA) batteries.
- The following sections show the technical details and configurations for NMC and Dx IT Data Centre battery rooms, respectively.

3.2.4.1 NMC battery room

- The current battery room for the NMC meets most of the specifications from the Battery Room Standard, 240-56177186.
- Although, the door's seal has dilapidated and as such, dust has found its way into the battery room, compromising the integrity of the equipment inside the battery room.
- Plumbing pipes are also leaking.

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- d) The fire-alarm has not been maintained in ages (unknown). It is unclear whether it still works or not.
- e) Figure 4 below shows the layout, dimensions and equipment in the NMC's battery room.

Figure 4: The existing NMC battery room layout

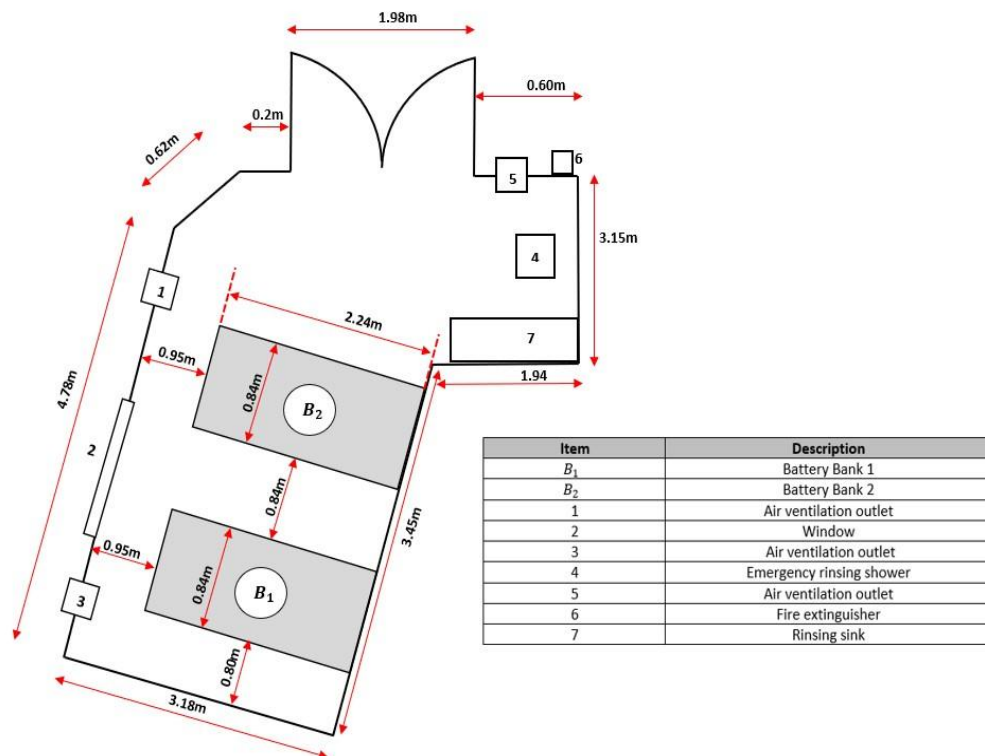


Table 3: The existing battery room specification (NMC)

Battery Room Specification	Dimensions [m]
Height of Battery Room	3.15
Door Height	2.55
Entrance Width	1.98
Battery Room Space	3.45 x 3.18 x 2

- f) The high-level assessment outcomes for the Simmerpan NMC battery room against the battery room standard are indicated in Table 4.

Table 4: NMC Battery Room General Conditions Based on the Standard

General Battery Room Standards	Current state	In Existence	Still Required
Battery rooms must have easy access for battery and battery stand installation	Good	✓	

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General Battery Room Standards	Current state	In Existence	Still Required
Battery rooms should be dry, well-lit, well-ventilated, and protected against dust and foreign matter	Poor, dust has found its way inside.		✓
Different types of electrolytes should not be in the same battery room. Batteries of the same type can be in the same room but on separate stands.	Good.	✓	
The minimum distance between any battery terminal and the nearest water outlet point should be at least 2000 mm.	Moderate	✓	
Battery stands should be positioned to not obstruct the doorway.	Good.	✓	
Stands should be perpendicular to the entrance wall to allow for an unobstructed escape path (minimum width of 600 mm) during emergency conditions	Excellent.	✓	
Battery rooms should allow for future plant expansion or refurbishment and be at the end of the building. They should be close to associated loads and power electronic equipment.	Good.	✓	

g) The high-level civil assessment outcomes for the Simmerpan NMC battery room are indicated in Table 5.

Table 5: NMC Battery Room Civil Works Conditions

Civil Requirement for a Battery Room	Current state	In Existence	Still Required
Fire Resistance	Water sprinklers are present the battery room, but the condition/state is unknown.	✓	
Floor Construction	Solid floor.	✓	
Floor Protection	The floor is made of tiles.		✓
Walls	Good, strong walls.	✓	
Windows	No windows present at the battery room.		✓
Ceilings	No ceiling present at the battery room.		✓
Doors	The door's seal has degraded.	✓	
Ventilation	The ventilation exists but its current state is unknown.	✓	

h) The high-level electrical assessment outcomes for the Simmerpan NMC battery room are indicated in Table 6.

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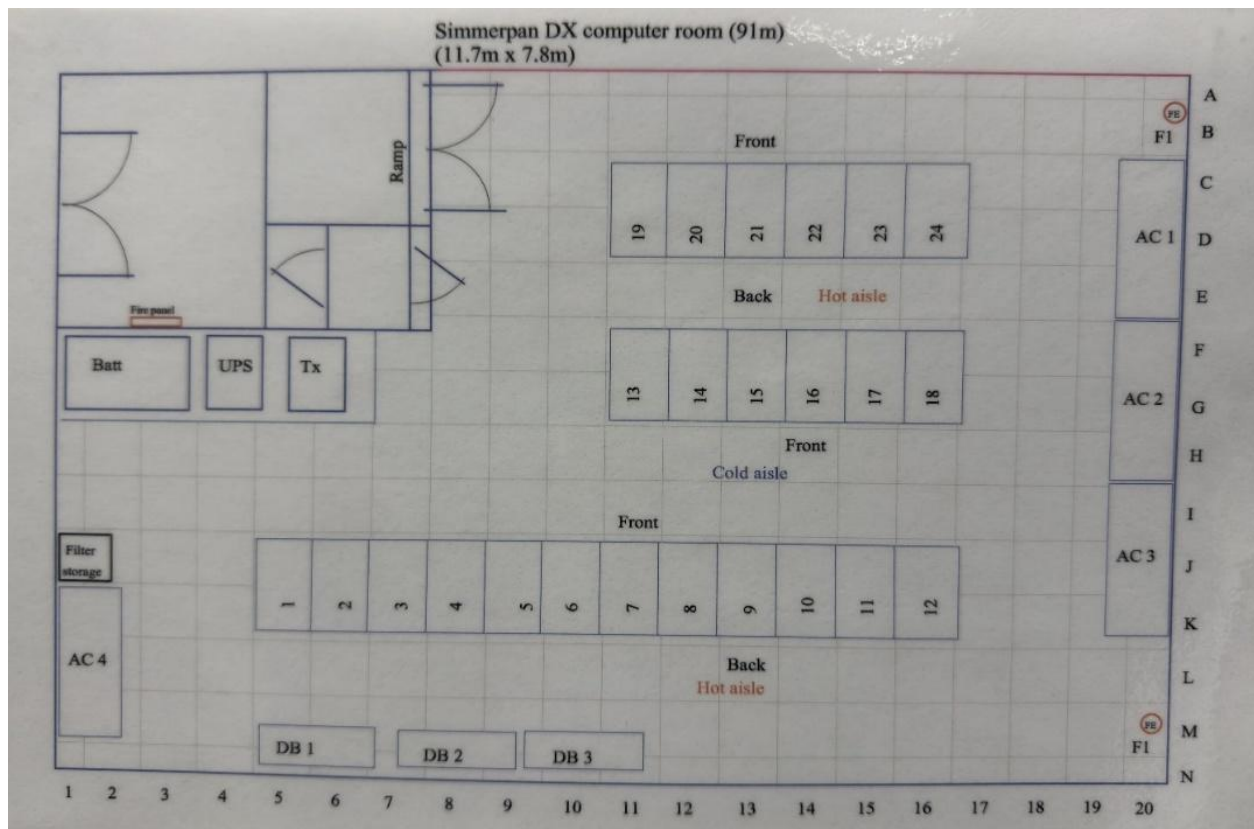
Table 6: NMC Battery Room Electrical Conditions

Electrical Requirement	Current state	In Existence	Still Required
Electrical equipment (classified zones)	Poor		✓
Cabling	Good	✓	
Lighting	Poor		✓

3.2.4.2 Dx IT Data Centre battery room

- The Dx IT Data Centre does not have a dedicated battery room which means that the battery banks are housed the same room that houses the UPS, servers, and other equipment. As a result, the batteries used for this system are the valve-regulated lead-acid (VRLA) batteries which follows the Specification for Valve-Regulated Lead-Acid Cells Standard, 240-51999453.
- There are four indoor Air Conditioning units inside the server room, and each is connected to the condensing units placed outside the entrance to the Dx IT Data centre.
- Figure 5 below shows the layout, dimensions and equipment in the Dx IT Data Centre.

Figure 5: The existing Dx IT Data Centre battery, UPS, and server room layout



- The high-level assessment outcomes for the Simmerpan Dx IT Data Centre room against the battery room standard are indicated in Table 7.

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Table 7: Dx IT Data Centre Battery Room General Conditions Based on the Standard

General Battery Room Standards	Current state	In Existence	Still Required
Battery rooms must have easy access for battery and battery stand installation	Good.	✓	
Battery rooms should be dry, well-lit, well-ventilated, and protected against dust and foreign matter	Excellent	✓	
Different types of electrolytes should not be in the same battery room. Batteries of the same type can be in the same room but on separate stands.	Good.	✓	
The minimum distance between any battery terminal and the nearest water outlet point should be at least 2000 mm.	Excellent	✓	
Battery stands should be positioned to not obstruct the doorway.	Good.	✓	
Stands should be perpendicular to the entrance wall to allow for an unobstructed escape path (minimum width of 600 mm) during emergency conditions	Excellent.	✓	
Battery rooms should allow for future plant expansion or refurbishment and be at the end of the building. They should be close to associated loads and power electronic equipment.	Good.	✓	

- e) The high-level civil assessment outcomes for the Simmerpan Dx IT Data Centre room are indicated in Table 8.

Table 8: Dx IT Data Centre Battery Room Civil Works Conditions

Civil Requirement for a Battery Room	Summary of the current state:	In Existence	Still Required
Fire Resistance	Water sprinklers are present the battery room, but the condition/state is unknown.	✓	✓
Floor Construction	The floor is raised by 0.346m. Has cables and ventilation running through.	✓	
Floor Protection	It's a raised access floor made of High-Density Chipboard.	✓	
Walls	Good, strong walls.	✓	
Windows	No windows present at the battery room.	✓	
Ceilings	Ceiling present at the battery room.	✓	

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Civil Requirement for a Battery Room	Summary of the current state:	In Existence	Still Required
Doors	There are two doors to the server/battery room, as a result there is very minimal dust.	✓	
Ventilation	The ventilation exists but few of the condensing units malfunction or don't work entirely.	✓	✓

- f) The high-level electrical assessment outcomes for the Simmerpan Dx IT Data Centre room are indicated in Table 9.

Table 9: Dx IT Data Centre Battery Room Electrical Conditions

Electrical Requirement for a Battery Room Standards:	Summary of current state:	In Existence	Still Required
Electromagnetic compatibility	N/A		✓
Electrical equipment (classified zones)	Poor		✓
Cabling	Good	✓	
Lighting	N/A		✓

3.2.5 Gap Assessment

- The two UPSs at the NMC are compatible with the input of 380-420 Vac and a DC bus voltage of at least 360 Vdc and the floating voltage of 405Vdc.
- The two UPSs at the Dx IT Data Centre are compatible with the input of 380-420 Vac and a DC bus voltage of at least 480 Vdc and the floating voltage of 540Vdc.
- The battery banks were recently replaced (2023). However, a comprehensive assessment is necessary to determine if the existing battery banks are adequate for the anticipated loads.
- The batteries present at the NMC are valve regulated lead acid batteries of 12V (30//30=60 Block) for each UPS with a bus voltage of 360Vdc. If the assessment indicates that the batteries are not adequate, the selected new batteries must have the bus voltage that is compatible with the new UPS modules.
- The batteries present at the Dx IT Data Centre are 12V (x40 Block) with a bus voltage of 480Vdc. If the assessment indicates that the batteries are not adequate, the selected new batteries must have the bus voltage that is compatible with the new UPS modules.
- The load connected to the Dx IT Data Centre is noticeably unbalanced.
- The installed NMC UPS 1 battery capacity is 81.6 kWh, similarly to NMC UPS 2, and the approximated load is at 18.1 kW. The standby hours should be approximately 4.5 hours, but the UPS shows that only 34 minutes is the estimated battery support time.

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- h) The supply points to the NMC's UPSs are from a Rose and Violet minisubs, but only the Rose minisub is currently supplying the building and the Violet minisub is the standby supply. The supply DB only caters for supply from either supply 1 (Rose) or supply 2 (Violet), meaning the current system does not cater for dual supply to the system.
- i) At the NMC building on the ground floor, there are two old 48 V, 1 kW DC rectifier/charger module (CXRC 48–1kW) packed with ALCAD CN119-2 Nickel-Cadmium Batteries (38//38 bank).
- j) The batteries installed at the NMC for the DC load are the Alcad CN119-2 nickel-cadmium cells configured as a 38//38 arrangement, with the approximated capacity of 11kWh and they are approximately 16 years old. They are connected via two 48 V, 1 kW CXRC rectifier/charger modules, with total capacity of 2kW.

3.3 High Level Scope of Work

The Contractor shall perform all activities necessary to deliver fully operational, integrated and compliant standby power systems for the Simmerpan NMC and Dx IT Data Centre. The scope includes assessment of the existing infrastructure, detailed design, procurement, supply, decommissioning, installation, integration, testing, commissioning, training, operation and maintenance support, and final handover.

- a) The Contractor shall:
 - 1) Conduct detailed site and reticulation assessments to verify the existing electrical infrastructure and standby power arrangements.
 - 2) Develop the complete engineering design, system studies, equipment sizing, protection philosophy, and associated technical documentation. The engineering studies shall include, as applicable, load-flow and demand assessment, prospective short-circuit calculation, protection coordination and discrimination, cable sizing and voltage-drop calculation, earthing and bonding assessment, harmonic assessment, generator transient and step-load analysis, UPS-generator compatibility, battery autonomy and recharge calculations, arc-flash risk assessment, fire risk assessment, HVAC heat-load assessment, and availability and single-point-of-failure analysis.
 - 3) Supply, install, and integrate all standby power system equipment (UPS systems, batteries, chargers, generators, automatic transfer switches, automatic static transfer switch, distribution boards, protection equipment, cabling), including associated electrical, control, monitoring (PMS), and communication systems.
 - 4) Table 10 shows the minimum requirement based on Eskom calculations as indicated in the appendices of this document, and if the bidder analysis and calculations propose different values with different rating, it shall be clearly proposed and motivated in the technical proposal and the deviation schedule.

Table 10: NMC and IT Data Centre minimum required equipment rating.

Site	Standby Generator [kVA]	UPS System		48V DC System	
		UPS [kVA]	Battery [kWh]	Charger [kW]	Battery [kWh]
NMC	125	2x 80	2x 200	2x 48 V, 2 kW	5.3
IT Data Centre	100	2x 60	2x 320	Not Required	Not Required

- 5) Decommission, remove, and dispose of redundant equipment where applicable.

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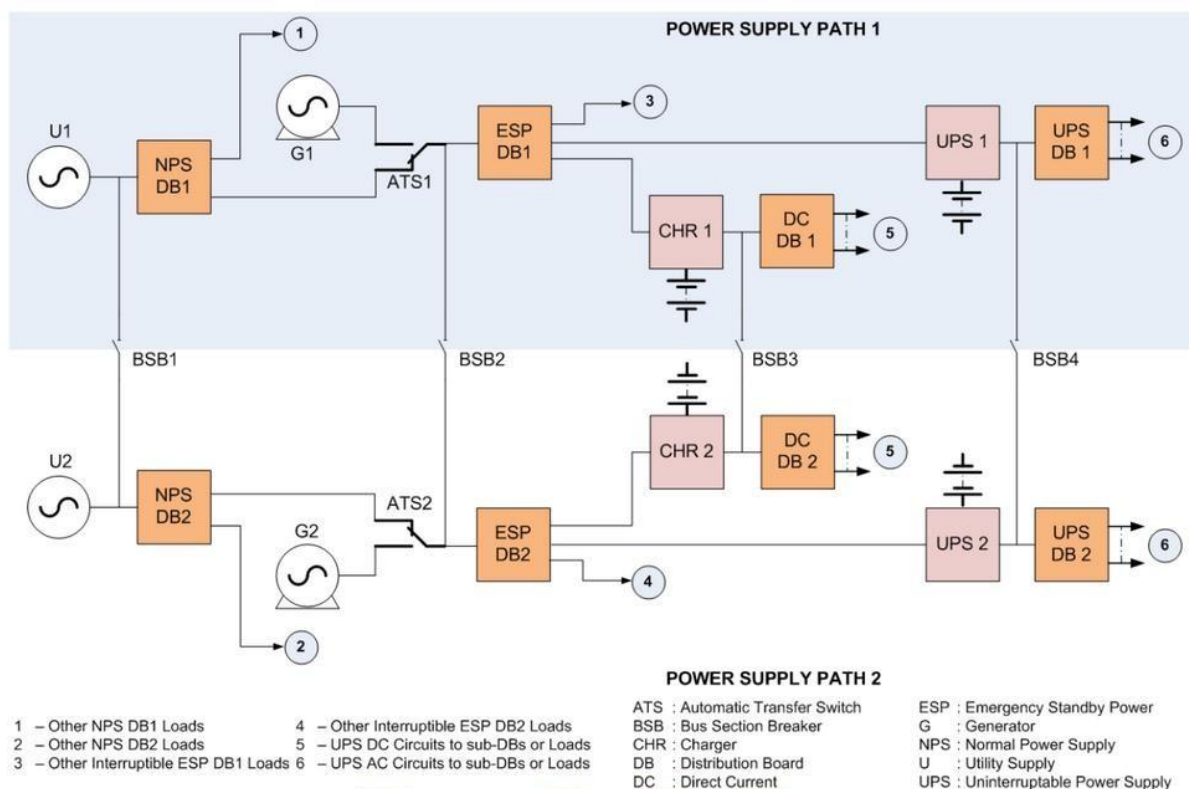
- 6) Execute all testing and verification activities to demonstrate compliance with the specified performance, reliability, redundancy, and safety requirements.
 - 7) Provide the operating and maintenance support for the specified period.
 - 8) Commission the complete system and provide OEM certified training, as-built documentation (simulations and design reports), GAs together other technical drawings, operating manuals and user manuals, test reports (FAT and SAT), equipment specific datasheets and warranty documentation as part of the final handover documentation
- b) The deliverable is a fully integrated, tested, commissioned, and operational standby power system that meets the NMC operational, reliability, redundancy, autonomy, and Eskom compliance requirements.

3.4 Detailed Scope of Work

3.4.1 Overall System Topology and Functional Requirements

- a) The recommended topology for Priority 1 site as per 240-118870219 is shown in Figure 6.
- b) The two project's sites fall under the Priority 1 site [Table 1 of 240-118870219], and as such, the Simmerpan NMC and Dx IT Data Centre Standby Power System and Anatomy will be implemented based on Figure 6.

Figure 6: Emergency Standby Power Systems single line block diagram for a Priority 1 site



- c) The topology provides two independent points of supply, U1 and U2, feeding two segregated UPS supply paths. The ultimate arrangement includes redundant generator capacity in accordance with the approved phased implementation strategy.

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Table 11: Required topologies and standby times for Priority 1 sites / facilities.

Site / Area	System	Topology	Standby Time [h]	
			System ¹⁾	Total
National Control Centre	48V DC	2N / 2(N+1)	4	168
Backup National Control Centre	UPS	2N / 2(N+1)	4	
Regional Network Management Centres	Generators	2N / 2(N+1)	TEB	
Tactical Command Centres				
Notes: 1) T _{EB} indicates the standby time covered by the generator fuel capacity. The other figures indicated refers to the standby time covered by the battery banks (T _{ES}).				

- d) From an operational perspective the following functional requirement needs to be fulfilled as per 240-118870219:
- 1) The site needs to be operational 24/7/365.
 - 2) Complete redundancy from the utility service entrance with separate power supply paths all the way to the critical loads.
 - 3) As far as possible the single points of failures shall be eliminated.
 - 4) The configuration shall be fault tolerant.
 - 5) Planned maintenance shall be possible on system components / sub-systems without affecting the connected load or without transferring the load to bypass mode, which would expose the load to unconditioned power.
 - 6) The HVAC systems shall also be dual redundant to ensure that the critical load equipment operates within their designed temperature range and to ensure that the environment in essential service areas remains comfortable for staff to continue.
 - 7) A Power Management System to monitor and control critical infrastructure shall be available at the NMC to show the status of all supplies (utility, generator, UPS systems, and DC systems) and the positions of all applicable switches.
 - 8) The NMCs are priority 1 facilities with required topologies and standby times indicated in Table.
- e) The detailed system operation is explained in 3.10.4 of 240-118870219, and it applies to both sites, NMC and Dx IT Data Centre buildings.
- f) The following applies to both NMC and Dx IT Data Centre standby power systems:
- 1) Each site is classified as a Priority 1 facility. Battery autonomy and generator fuel endurance shall comply with Table 11 and Document 240-118870219, including four hours of battery autonomy per independent UPS or DC supply path and total site endurance of 168 hours.
 - 2) It should be a Dual Redundant UPS System 2(N+1), as shown in Figure 6.
 - 3) Aiming for a design that will give the highest reliability and availability.

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- 4) As for the NMC building two independent supplies will be sourced from Rose and Violet minisubs, respectively as represented by U1 and U2 in Figure 6. The cables may require replacement.
- 5) The Dx IT Data Centre has only one supply, sourced from Pansy minisub, via an ATS in connection with a single generator in proximity with the minisub, outside the Data Centre.
- 6) The Dx IT Data Centre shall be supplied from Pansy minisub as U1 and HV Lab minisub as U2 as shown in Figure 6.
- 7) And for both systems, unlike the two generators show in Figure 6 for redundancy, the contractor shall design a system that will temporarily be connected via a single stationary generator in each site, which means the generator should be able to supply both power supply paths in case of U1 and U2 failing.
- 8) The design should allow a seamless integration of a second stationary generator in each standby power system.
- 9) IT Data Centre site does not have DC loads, as a result, CHR1/CHR2 together with their batteries and DC DB1/DC DB2 will be omitted from the implementation.
- 10) NMC site has 50V DC loads. The new system shall be a 50V dual battery charger with DC DB1 and DC DB 2, together with a single corded DC DB via the DCC (Diode Combiner Circuit). The standard battery chargers available on contract shall be used for this purpose.
- 11) All the interruptible loads will be connected via the ESP DB1 and ESP DB2 (3 and 4 loads) as shown in Figure 6.
- 12) With ESP DB1 connecting to the ground floor essential loads/DB and ESP DB2 connecting to the first-floor essential loads/DB.
- 13) The present identified uninterruptable loads are single corded loads, as a result Figure 6 of 240-118870219 shall be utilized to connect to the uninterruptable loads.
- 14) The identified uninterruptable loads are as follows:
 - i) Server/SCADA room (Ground Floor) – Load is known. The equipment is capable of being supplied through a dual-corded configuration and shall be connected via UPS DB 1 and UPS DB 2 to ensure redundant power supply.
 - ii) Network Management Centre office (1st Floor) – Load is known
 - iii) Resource Management Centre office (1st Floor) – Load is known
 - iv) Security Monitoring Room (1st Floor) – Load is unknown. These load circuits and load values shall be verified by the contractor.
 - v) SCADA support office (Ground Floor) – Load is unknown. These load circuits and load values shall be verified by the contractor.
- g) An ASTS (see Figure 6) shall be used to connect the single corded loads via PDU 2. A provision for the dual corded loads shall be made by providing PDU 1 from UPS 1 and PDU 3 from UPS 3.
- h) The ATS supplied shall be designed and built as a fully integrated, maintenance free product (power switching, motorisation and ATS Control), shall be of the same recognized manufacturer and shall be tested to [6.2.4.1] IEC 60947-6-1 as one complete unit.

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- i) The change-over switching device shall be both electrically and mechanically interlocked in such a way that the main supply and the alternative supply cannot be connected to the installation or part of the installation at the same time.
- j) The contractor shall provide a clear automatic switching procedure that ensures a safe and reliable supply to the connected load equipment. The control system that provides this functionality shall be user friendly, easily configurable, maintainable and widely supported.

3.4.2 UPS Specification

- a) The offered UPS Systems shall comply with the requirements of 240-53114248, Thyristor and Switch Mode Chargers, AC/DC to DC/AC Converters and Inverter / Uninterruptible Power Supplies Standard, and application specific requirements stated in the respective Schedule A of the issued Technical Schedules A&B.
- b) As stipulated in 240-118870219, there must be two modular and scalable Uninterruptible Power Supplies 1 & 2, that must be implemented at the Distribution NMC and Dx IT Data Centre buildings, respectively. There shall be a 2(N+1) system.
- c) The UPS shall form part of the 2N redundant system, forming two independent supply paths to uninterruptable loads via two separate UPS as shown in Figure 6 of 240-118870219 per building (NMC and Data Centre).
- d) The new UPSs for both sites must be compatible with South African input 3 phase voltages.
- e) The UPS shall be integrated to the Power Management System (PMS), which enable the NMC to monitor the status of UPSs and have control of both the standby power systems.
- f) Major and minor alarms shall be hard-wired per system, to the NMC, with the redundancy 2x per system.
- g) The Contractor shall provide an approved monitoring and control point schedule for the UPS, battery management system, generators, ATS/ASTS, distribution boards, HVAC and auxiliary systems. The schedule shall define each status, analogue value, alarm, control permission, protocol, fail-safe state, time synchronisation requirement and destination within the PMS or other Eskom system.
- h) Remote access and network integration shall comply with 32-373, 240-55410927, 240-79669677 and 240-64038621. The design shall include role-based access control, unique user accounts, password management, event and audit logging, configuration backup and restoration, secure firmware management, disabling of unused services, and an Eskom-approved remote-support method. No uncontrolled modem or direct internet connection shall be permitted.
- i) Rectifier sized to supply the load and to recharge the 4-hour standby batteries to 80% of rated capacity in a maximum of 10 hours.

3.4.2.1 NMC UPS Specification

- a) Two independent 80 kVA, online UPS systems arranged in a true 2N / 2N+1 configuration, each capable of supplying 100% of the critical load.
- b) A minimum power factor of 0.95 shall be applied to each UPS.

3.4.2.2 Dx IT Data Centre UPS Specification

- a) The contractor shall ensure that the load is significantly balanced before installing the new UPSs.

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- b) Two independent 60 kVA, online UPS systems arranged in a true 2N / 2N+1 configuration, each capable of supplying 100% of the critical load.
- c) A minimum power factor of 0.95 shall be applied to each UPS.

3.4.3 Utility AC Power Supply Specification requirements

- a) In compliance with the requirements for a Priority 1 site, as defined in Section 3.10.2 of the Standby Power Systems Topology and Autonomy for Eskom Sites (Document 240-118870219), the utility (grid) power supplies feeding the UPS systems shall be derived from fully independent and segregated electrical supply paths.
- b) Independence shall be achieved upstream of the distribution level and shall not be limited to separation at a distribution board. The provision of multiple feeders originating from the same Normal Power Distribution Board (NPDB) shall not be considered acceptable compliance with this requirement.
- c) The contractor shall assess the cables present at both sites to determine if they are suitable for the application.

3.4.3.1 NMC Power Supply Specification

- a) Two (2) separate cable supply systems to make up the 2N system.
- b) One from Rose minisub and the other from Violet minisub.

3.4.3.2 Dx IT Data Centre Power Supply Specification

- a) Two (2) separate cable supply systems to make up the 2N system.
- b) Supply U1 will be from the existing supply from Pansy minisub.
- c) A new cable shall be installed to create a second supply U2 from the HV Lap minisub.

3.4.4 Battery Specification

- a) The offered batteries shall comply with the following requirements, in order of preferred technology:
 - 1) 240-170000103, Lithium Iron Phosphate Batteries Standard.
 - 2) 240-56360034, Stationary Vented Lead Acid Batteries Standard.
 - 3) 240-51999453, Standard Specification for Valve-Regulated Lead-Acid Cells.
 - 4) 240-56360086, Stationary Vented Nickel Cadmium Batteries Standard.
- b) The contractor shall first ascertain if the required battery capacities are available on Eskom Distribution National Contracts and use these.
- c) If the required battery capacities are not available on Eskom Distribution National Contracts, then the applicable Technical Schedules A&B shall be duly completed with supporting evidence to proof compliance to the aforementioned standards.
- d) The Standby time per UPS shall be 4 hours for each battery bank for the NMC UPSs, NMC chargers and Dx IT Data Centre UPSs, respectively, as stated in Table 11. As such the battery capacity for both sites, should at minimum cover 4 hours standby time.

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- e) The battery expected end-of-life capacity shall be not less than 80% of its rated capacity.
- f) The required battery capacities shall be calculated in accordance with the 240-91190310, Sizing of DC Systems for Substation Applications standard, where applicable or the relevant IEC standard.

3.4.4.1 NMC UPS Battery Specification

- a) The VRLA batteries at the NMC battery room will be replaced with the Lithium Iron Phosphate (LiFePO₄, LFP) batteries. Lithium Iron Phosphate Standard 240-170000103 shall be applied.
- b) The battery room shall be refurbished to comply with the requirements of Battery Room Standard, 240-56177186.
- c) The battery shall give a minimum autonomy of 4 hours, and a minimum of 230 kWh required usable energy.
- d) A minimum of **320 kWh** installed battery capacity is required to guarantee 230 kWh at end of life.
- e) Each UPS battery system shall use a nominal DC bus voltage compatible with the selected UPS. A nominal 480 VDC arrangement may be proposed, subject to the OEM design, final battery sizing, fault calculations, protection design, maintainability and available space.
- f) One independent battery bank of not less than 667 Ah at the selected nominal DC voltage shall be provided for each UPS supply path. The two independent UPS and battery paths together shall form the required 2N architecture.

3.4.4.2 NMC DC Battery Specification

- a) The usable capacity at this (end) cycle-life shall be specified. A minimum of 110 Ah shall be installed.
- b) 2 × 50 V, 110 Ah cabinet-mounted LiFePO₄ battery systems with independent modular chargers and DC distribution boards, arranged in a true 2N/2(N+1) architecture as shown in Figure 6.
- c) At 50 V, each battery bank should have a minimum capacity of 5.5 kWh per charger in a 2N configuration.

3.4.4.3 Dx IT Data Centre UPS Battery Specification

- a) The VRLA batteries at the Dx IT Data Centre room will be replaced with the Lithium Iron Phosphate (LiFePO₄, LFP) batteries. Lithium Iron Phosphate Standard 240-170000103 shall be applied.
- b) The replacement battery technology for the Dx IT Data Centre shall be lithium iron phosphate (LiFePO₄/LFP) in accordance with 240-170000103. Any alternative battery technology shall require a documented technical deviation and prior Eskom acceptance.
- c) The battery shall give a minimum autonomy of 4 hours, and a minimum of 144 kWh required usable energy.
- d) A minimum of 200 kWh installed battery capacity is required per UPS battery bank to provide approximately 144 kWh usable energy at end of life, based on a maximum depth of discharge of 90% and an end-of-life capacity of 80%.

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- e) Each UPS battery system shall use a nominal DC bus voltage compatible with the selected UPS. A nominal 480 V DC arrangement may be proposed, subject to the OEM design, final battery sizing, fault calculations, protection design, maintainability and available space.
- f) One independent battery bank of not less than 420 Ah at the selected nominal DC voltage shall be provided per UPS. The final ampere-hour rating shall be confirmed by the OEM battery sizing calculation for four-hour end-of-life autonomy.
- g) The factory-engineered UPS battery cabinets shall be utilized because of limited space

3.4.5 NMC Charger requirements

- a) The contractor shall first ascertain if the required battery charger capacities are available on Eskom Distribution National Contracts and use these.
- b) The charger shall be redundant $2(N+1)$. Each charger shall be sized to continuously support 20 A connected DC load while continuously recharging the battery bank from a discharged condition with 8 hours.
- c) A minimum of **2x 48 V, 2 kW 40 A** charger shall be installed.
- d) If the required battery charger capacities are not available on Eskom Distribution National Contracts, then the applicable Technical Schedules A&B shall be duly completed with supporting evidence to proof compliance to Eskom Specification 240-53114248, Thyristor and Switch Mode Chargers, AC/DC to DC/AC Converters and Inverter / Uninterruptible Power Supplies Standard.

3.4.6 Standby Generator requirements

- a) The existing standby generators at the NMC and IT Data Centre shall be decommissioned and replaced.
- b) The replacement generator shall fully comply with all applicable performance, reliability, and operational requirements to ensure uninterrupted operation of the Network Management Centre.
- c) For both sites, the standby power system shall initially be designed to operate with a single generator capable of supplying both independent power supply paths (U1 and U2) should both utility supplies fail. The design shall, however, allow for the seamless future integration of a second generator to achieve full generator redundancy.
- d) There shall be a second ATS installed for easy integration of an additional generator in future.
- e) If in each site both U1 and U2 fails, the single generator shall be installed in a way that it supplies both paths until another generator is installed in future.
- f) The standby generators shall comply with 240-62772907, Specification for Stationary Diesel Generator Systems.
- g) The generator design shall include fuel storage and replenishment arrangements sufficient to meet the required total site endurance, subject to statutory, environmental and fire-safety requirements. The Contractor shall document usable fuel volume, consumption at defined load points, refuelling strategy, fuel-quality management and the effect of auxiliary loads.

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- h) The single-generator interim arrangement shall be identified as a phased deviation from the ultimate Priority 1 topology. The detailed design shall demonstrate that the common generator connection does not create an uncontrolled single point of failure between the two utility and UPS supply paths, and shall define isolation, maintenance, failure and future second-generator integration arrangements.
- i) The technical specification document for the NMC Generator Replacement has been finalized, and the contractor shall adhere strictly to its requirements, in conjunction with Standard Document 240-62772907, for the execution and implementation of the standby generator replacement at the NMC.

3.4.6.1 NMC Generator

- a) A single stationary diesel generator shall be installed at the NMC through the approved automatic transfer and distribution arrangement supplying all the essential loads.
- b) The diesel generator must be able to carry all the load at the NMC building continuously and not exceed 75% of the applicable generator rating.
- c) The preliminary NMC generator rating is 125 kVA at 400 V, 50 Hz and 1500 r/min, ESP-rated. The Contractor shall confirm the final rating through steady-state and transient generator sizing studies, including UPS input characteristics, battery recharge demand, motor starting, HVAC load, load sequencing, harmonic effects, future growth, ambient derating and the requirement that normal operating load does not exceed 75% of the applicable generator rating.

3.4.6.2 Dx IT Data Centre

- a) A single stationary diesel generator shall be installed at the NMC through the approved automatic transfer and distribution arrangement.
- b) The diesel generator must be able to carry all the load at the Data Centre building continuously and not exceed 75% of the applicable generator rating.
- c) The preliminary Dx IT Data Centre generator rating is 100 kVA at 400 V, 50 Hz and 1500 r/min, ESP-rated. The Contractor shall confirm the final rating through steady-state and transient generator sizing studies, including UPS input characteristics, battery recharge demand, HVAC and auxiliary loads, load sequencing, harmonic effects, future growth, ambient derating and the requirement that normal operating load does not exceed 75% of the applicable generator rating.

3.4.7 UPS Distribution Boards and Cable Work

- a) The existing standby power system reticulation at both the NMC and Dx IT Data Centre is not adequately documented, and the up-to-date reticulation drawings are not available for the clear identification of distribution boards (DBs) and associated cabling.
- b) The Contractor shall therefore first undertake a comprehensive reticulation assessment of the existing reticulation for both sites. Based on this assessment, the Contractor shall develop as-built drawings reflecting the current configuration of the systems to be replaced. The finalised reticulation drawings and associated report of the existing and as-built shall be submitted to and shared with Eskom for review and record purposes.
- c) The distribution boards for the standby power systems at both the NMC and Dx IT Data Centre shall be designed and configured in accordance with the DB arrangement illustrated in Figure 6 of Standard Document 240-118870219.

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- d) The existing UPS configuration shall be replaced with a dual independent Normal Power Supply (NPS) distribution board arrangement (NPS DB1 and NPS DB2), providing segregated supply 1 and supply 2 feeds to all essential and critical loads.
- e) Single-corded equipment shall be connected to both the UPSs via an ASTS.
- f) Dual-corded equipment shall be supplied via two independent supply paths, with one feed originating from UPS DB1 and the second feed originating from UPS DB2.
- g) Each UPS distribution board shall supply the respective distribution boards serving the critical service areas. Each critical area shall be provided with both UPS DB1 and UPS DB2, from which all critical loads shall be independently and redundantly supplied.

3.4.8 Drawings

- a) The consultant shall develop comprehensive reticulation drawings for the new UPS configuration for both sites.
- b) Cable block diagrams shall be provided for the complete systems as well as all modified subsystems, including power electronic equipment and communication connections.
- c) OEM equipment manuals and technical specifications shall be supplied for all installed equipment.
- d) Updated drawings for any new or modified Distribution Boards shall be provided and fitted with appropriate and clearly labelled nameplates.

3.4.9 General

- a) All applicable legislation, statutory requirements, and regulations not explicitly referenced within this specification for the standby power system installations shall remain fully binding and shall be strictly adhered to.
- b) Certificates of Compliance (CoCs) shall be issued for all newly installed distribution boards (DBs) and associated systems, as well as for any DBs and systems that are modified, upgraded, or otherwise altered during the execution of the Works.
- c) Any cabling identified as redundant, including newly installed or existing infrastructure rendered obsolete, shall be removed and disposed of in accordance with applicable Eskom processes, environmental and waste management regulations.
- d) All associated decommissioned equipment and accessories shall be returned to Eskom in accordance with the applicable asset recovery and disposal procedures.
- e) All batteries removed from both the NMC and IT Data Centre shall be returned to Eskom following replacement, in accordance with Eskom's prescribed asset handling and return procedures.

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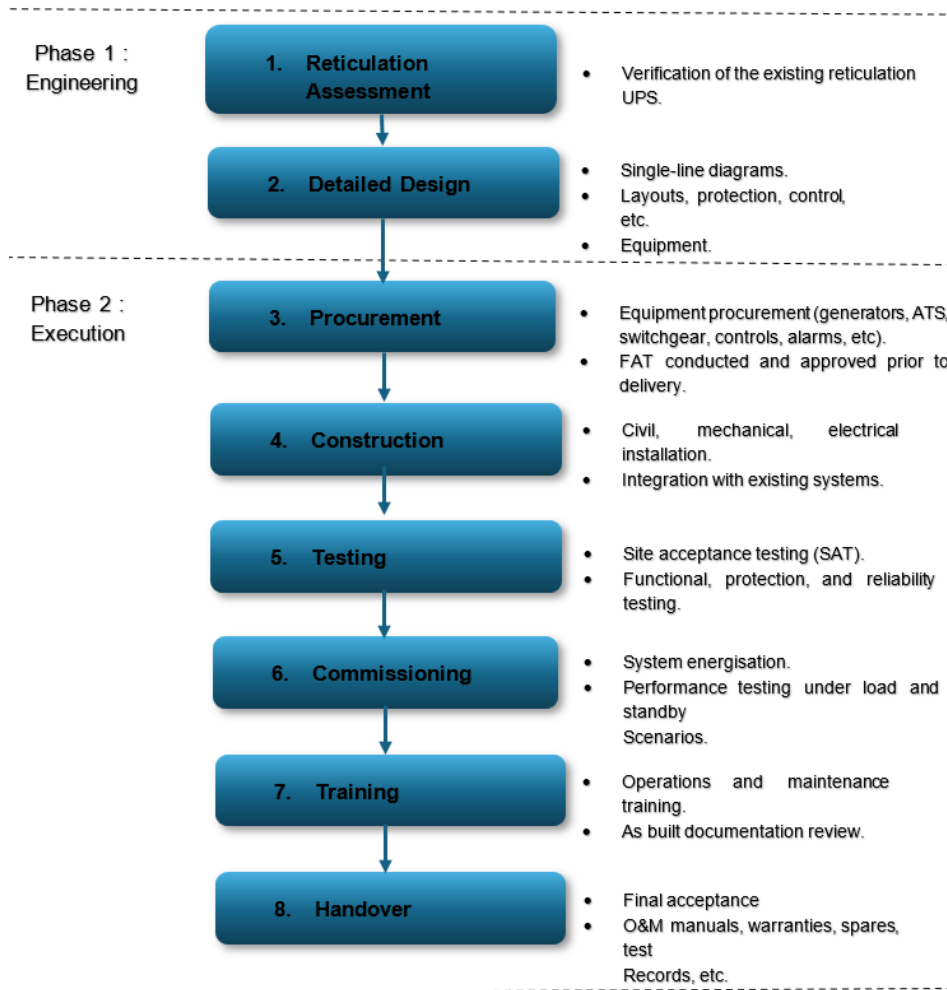
3.5 Contractor

3.5.1 Execution

- a) The Contractor shall undertake all specified assessments and submit the corresponding results and reports to Eskom for review and approval. Eskom's input shall be duly considered and may inform or modify subsequent procedures. The outcomes of these assessments shall determine the appropriate sizing and selection of equipment required for the replacement of the standby power system at both the NMC and IT Data Centre.
- b) The assessment shall include a detailed cut-over, rollback and temporary-supply plan that prevents unplanned interruption of the NMC, Dx IT Data Centre and other essential services. Planned interruptions shall be subject to Eskom approval and formal outage coordination.
- c) The Contractor shall be responsible for the complete detailed design, supply, delivery, installation, and commissioning of all equipment necessary to implement the proposed solution.
- d) The Final Design Pack (FDP) shall be presented for acceptance at the regional Design Review Team (DRT) before proceeding with execution.
- e) The Final Design Pack shall include a clause-by-clause compliance matrix linking each URS requirement to the relevant design document, calculation, drawing, equipment data sheet, test or deviation.
- f) No procurement or construction affecting the final design shall commence before formal design acceptance and closure or approved disposition of review comments.
- g) All activities executed under this scope shall comply fully with Eskom's Life-Saving Rules and all applicable site-specific regulations and safety requirements.
- h) At least one (1) Month prior to commissioning, start-up, and/or functional energisation (livening) tests, the Contractor shall submit the following documentation to the Employer for review and comment:
 - 1) A final commissioning plan and procedure outlining the detailed steps required to commission the plant.
 - 2) A plant readiness checklist to be used to verify safe and complete preparation prior to start-up.
 - 3) A comprehensive start-up and shutdown procedure, including defined emergency and catastrophic failure shutdown protocols.
 - 4) Upon completion of the Works, all areas affected by civil, mechanical, structural, or any other temporary modifications necessary for execution of the Works shall be reinstated to their original condition.
- i) The implementation of the standby power system replacement will be divided into two phases, and their subsequent processes are shown in the Figure 7 below.

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Figure 7: Standby Power System Replacement Project Phases



3.5.2 Responsibility Assignment Matrix (RACI)

Table 12: Project RACI

Activity	Contractor	Distribution Real Estate	Distribution Technology and Engineering	Distribution Gauteng Operating Unit
Project governance, technical approval, and final acceptance	I, R	A, R	C	R
Site access, building ownership, facilities, and infrastructure approvals	I, R	A, R	C	I
Operational requirements, outage coordination, and operational acceptance	I, R	A, R	C	C

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Activity	Contractor	Distribution Real Estate	Distribution Technology and Engineering	Distribution Gauteng Operating Unit
Design, supply, installation, testing, commissioning, and documentation of the standby power system	R	A, R	C	C
Compliance with Eskom standards, legislation, and quality requirements	R	A, R	C	C
Project oversight, progress monitoring, and stakeholder coordination	R	A, R	C	C

3.5.3 Key Personnel Competency Requirements

- a) The Contractor shall appoint suitably qualified, professionally registered and experienced personnel for the duration of the Project. The proposed personnel shall collectively demonstrate competence in the assessment, design, implementation, testing, commissioning, operation and maintenance of mission-critical standby power systems, including utility supplies, UPS systems, battery systems, DC systems, standby generators, ATS/ASTS systems, protection systems, power-management systems and associated monitoring and communications.
- b) Personnel shall not be replaced without Eskom's prior acceptance of a replacement having equivalent or superior qualifications and experience.

3.5.3.1 Lead Electrical Design Engineer

The Lead Electrical Design Engineer shall:

- a) be registered with the Engineering Council of South Africa as a Professional Engineer (Pr Eng) or Professional Engineering Technologist (Pr Tech Eng) in the electrical engineering discipline, and be in good standing;
- b) have at least five years of relevant post-registration experience in electrical power-system design;
- c) have successfully completed at least three projects involving critical or mission-critical electrical infrastructure, including UPS systems, standby generators, battery systems and associated low-voltage reticulation;
- d) demonstrate experience in system architecture, redundancy and maintainability assessments, load and equipment sizing, fault-level studies, protection coordination, earthing, battery autonomy, UPS-generator compatibility, commissioning and performance verification; and
- e) take professional responsibility for the electrical design, design calculations, engineering studies, design reports and final design documentation within the person's area of competence.

3.5.3.2 Mission-Critical Infrastructure Competence

- a) The Contractor shall provide at least one key design resource with demonstrable experience in mission-critical facilities.

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- b) A current Uptime Institute Accredited Tier Designer (ATD), Accredited Tier Professional (ATP), Certified Data Centre Design Professional (CDCDP), Data Centre Certified Associate (DCCA), or an equivalent recognised mission-critical infrastructure credential shall be regarded as evidence of specialist development.
- c) No single named certification is mandatory where the Tenderer demonstrates equivalent competence through relevant training and successfully completed comparable projects.

3.5.3.3 Commissioning Lead

- a) The Commissioning Lead shall have at least five years of relevant commissioning experience and shall have completed at least three critical-power projects involving UPS systems, standby generators, battery systems, transfer switching and integrated controls.
- b) Personnel who configure, test or commission proprietary equipment shall hold current OEM training or certification applicable to the offered equipment where such OEM authorisation is required.

3.5.3.4 Protection and Power-System Studies Specialist

- a) The Contractor shall appoint a suitably qualified electrical engineer or engineering technologist responsible for prospective short-circuit, protection-coordination and discrimination, arc-flash, earthing, harmonic, load-flow and related power-system studies.
- b) The resource shall demonstrate experience with recognised analysis software suitable for the required studies. Equivalent software shall be acceptable, provided its suitability, validation and application are demonstrated.

3.5.3.5 Project Manager

- a) The Project Manager shall have at least five years of relevant experience managing multidisciplinary electrical infrastructure projects of comparable complexity.
- b) A recognised project-management qualification or professional designation is preferred but shall not replace the requirement for relevant project-delivery experience.

3.5.3.6 Evidence and Acceptance

- a) The Tenderer shall submit an organogram, role and responsibility schedule, certified proof of professional registration, current curricula vitae, relevant qualifications and certifications, and a project-reference schedule for each key resource.
- b) Project references shall identify the facility, scope, system ratings, role performed, completion date and a contactable client representative.
- c) Eskom reserves the right to verify professional registration, certification and project references.
- d) Where one person is proposed for more than one key role, the Tenderer shall demonstrate that the person has the required competence, capacity and availability to perform each role without creating project-delivery or assurance risk.

3.5.4 Site Acceptance Testing

- a) The site acceptance tests shall be conducted for both sites, the NMC and Dx IT Data Centre.

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- b) The Contractor shall submit a comprehensive Site Acceptance Testing (SAT) plan for review, comment, and acceptance by the Employer. All components and subsystems shall be tested and demonstrated to comply with the specified technical and functional requirements.
- c) All tests shall be witnessed by the employer (Eskom), and each test shall be formally acknowledged by signature. It is noted that witnessing of tests does not constitute acceptance or confirmation of compliance.
- d) As a minimum, besides equipment specific technical tests, the SAT shall include confirmation by way of demonstration that ALL functional and safety requirements have been met.
- e) The SAT shall include approved pass/fail criteria for loss and restoration of each utility source, generator start and load acceptance, ATS and ASTS transfers, loss of one UPS path, inverter and bypass modes, maintenance bypass, overload and alarm operation, emergency stop and safe isolation, BMS alarms, PMS/SCADA point-to-point verification, protection operation, phase rotation, load balancing, thermal inspection, black-building recovery, and restoration to normal operation.
- f) Battery autonomy shall be demonstrated by an approved discharge or equivalent capacity test at the agreed load. Where a full four-hour site discharge is operationally impracticable, the Contractor shall submit a technically justified alternative verification method for Eskom acceptance before testing.

3.5.5 Training

- a) A minimum of one formal training session per training category shall be conducted for up to 10 attendees. Training shall be delivered by qualified personnel and shall include both theoretical instruction and practical demonstrations to ensure a thorough understanding of system operation, monitoring, operating and maintenance.
- b) The following categories shall be prepared as part of training; however, the scope is not limited to these items.

3.5.5.1 System Overview, and Hardware Training

- a) The Contractor shall provide comprehensive system-wide training on all hardware components associated with the solution. This shall cover the Battery Energy Storage System (BESS), Uninterruptible Power Supplies (UPS), power supplies, cabling, protective devices, control and monitoring systems, communication infrastructure, SCADA cabling, and associated hardware. The training shall also address broader aspects related to the design, operation, and monitoring of backup systems.
 - 1) Backup System Overview
 - i. Provide a detailed overview of the backup system, highlighting key components such as UPSs, power supplies, batteries, and monitoring systems
 - ii. Explain system design principles, including energy distribution optimization and site-specific design considerations.
 - 2) Safety and Emergency Procedures
 - i. Conduct safety training to ensure all personnel are aware of potential hazards associated with battery installations and other hardware.

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- ii. Provide guidance on handling emergency situations and crisis management specific to battery systems and UPS operations.
- 3) System Integration and Design
 - i. Instruction on electrical and mechanical integration of the hardware with existing infrastructure.
 - ii. Guidance on grid interconnection requirements, utility regulations, regional permitting processes, and documentation standards.
- 4) Battery Management
 - i. Detailed training on battery management principles, including charging and discharging cycles, routine maintenance, and safety procedures.
 - ii. Explanation of battery system monitoring and reporting requirements.
- 5) Quality Control and Testing
 - i. Overview of quality control measures and testing procedures to ensure reliability and compliance with design specifications.
 - ii. Guidance on configuring and testing UPS and power supply settings, integration with the Battery Management System (BMS), paralleling configurations, and modes of operation.
- 6) Basic System Operation and Monitoring
 - i. Provide instruction on the basic operation, monitoring, and troubleshooting of all hardware components within the system.
 - ii. Training shall ensure that personnel are capable of independently managing system performance and responding appropriately to alerts or abnormal conditions.

3.5.5.2 SCADA and Network Administration Training (for PMS).

- a) The Contractor shall provide in-depth training on all communications and SCADA functionalities associated with the solution. The training shall include the following:
 - 1) Communications Systems Overview
 - i. Detailed instruction on all communication protocols deployed as part of the solution, including serial, parallel, and Ethernet-based systems.
 - ii. Explanation of data flow processes, including how operational data is collected, aggregated, and transmitted, how alarms are generated, and how control commands are sent and executed.
 - iii. Overview of the Application Programming Interface (API) supported by the system, including practical usage examples and integration guidance.
 - 2) System Failure Modes and Recovery
 - i. Description of typical failure modes for communication and SCADA systems, including potential operational impacts.
 - ii. Guidance on backup procedures, recovery strategies, and mitigation measures to ensure business continuity in the event of system faults or failures.
 - 3) SCADA System Features and Functionality

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- i. Comprehensive training on SCADA system capabilities, including configuration of the existing system and procedures for integrating new or future systems.
- ii. Instruction on managing users, including roles, permissions, and access control.
- iii. Guidance on the creation, configuration, and management of Human-Machine Interfaces (HMIs) to enable effective system monitoring and control.

3.5.5.3 Operation and Maintenance (O&M) Training

- a) The Contractor shall provide comprehensive training, guidance, and support for the operation, monitoring, and maintenance of the installed system.
- b) The course material shall comply with Eskom standard requirements.
- c) The scope shall include the following:
 - 1) Day-to-Day Monitoring and Operational Guidance
 - i. Detailed instructions shall be provided for daily monitoring, control, and maintenance activities.
 - ii. The Contractor shall cover the identification, interpretation, and appropriate response to all system errors, warnings, notices, alerts, and operational data requiring corrective or preventive action.
 - iii. Any specific operational requirements that affect system warranties shall also be explained.
 - 2) Life-Cycle Maintenance Plan
 - i. A complete life-cycle maintenance regimen for the system shall be provided, covering all scheduled inspections, servicing, component replacements, and long-term maintenance strategies to ensure system reliability and optimal performance.
 - 3) Equipment Failure Modes and Recovery
 - i. Typical equipment failure modes shall be described, including how each component may fail and the associated causes.
 - ii. Recommended recovery, replacement, or corrective procedures shall be included.
 - iii. Equipment with historically higher failure rates shall be identified, and guidance on mitigating these risks shall be provided.
 - 4) Preventative Maintenance
 - i. Detailed preventative maintenance tasks shall be defined, including procedures, recommended intervals, tools and resources required, and associated safety measures.
 - 5) Monitoring System Utilization
 - i. Guidance on the effective use of system monitoring and diagnostic tools shall be provided to:
 - Track and report system performance metrics.
 - Identify operational trends and opportunities for efficiency improvements.
 - Support routine maintenance tasks, including cleaning, inspections, diagnostics, and troubleshooting.

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6) Warranty Provisions and Claims

- i. Detailed information on the warranties for each system component shall be provided, including coverage scope, duration, limitations, and exclusions.
- ii. The process for submitting and managing warranty claims shall be clearly explained.

7) Emergency Response Procedures

- i. The Contractor shall provide a documented emergency response plan that addresses actions to be taken in the event of system failure, abnormal operating conditions, or safety incidents.
- ii. Procedures for safe shutdown, isolation, and recovery shall be included, ensuring personnel can respond effectively to emergency situations.

8) As part of the O&M documentations for training, the contractor shall provide a maintenance scope for the systems. The scope will assist with maintenance contracts after the O&M period.

3.5.6 Spares Provision

- a) The Contractor shall provide spare components to support the reliable operation and maintenance of the installed systems. All spare equipment shall be fully compatible with the deployed systems and, where applicable, interchangeable across the site's standby power systems to ensure flexibility and operational continuity. The Contractor shall ensure that spares are of similar specification or compatible design with the installed equipment. These spares are meant for maintenance, quick fault replacement and minimizing downtime.
- b) The Contractor shall submit a recommended critical-spares schedule derived from the failure-mode assessment, OEM lead times and the required restoration time. The schedule shall include, where applicable, UPS and charger power modules, fans, control and communication cards, battery/BMS modules, fuses, generator filters, belts, hoses, starter batteries, ATS/ASTS control components, indication lamps and specialised tools or configuration devices. Spares that affect availability, reliability and safe operation shall be top of mind recommending spares.
- c) All spares shall be delivered, documented, and clearly identified to facilitate future replacement or maintenance. The Contractor shall ensure that spares meet the same quality, performance, and safety standards as the installed equipment. Spares shall be stored and packaged appropriately to prevent damage during transport and handling. Spares to be handed over to Plant Department as part of critical spares.

3.5.7 Warranties

- a) The Contractor shall provide a minimum 24-month system warranty from the commercial operation date. Any longer OEM warranty shall be transferred to Eskom and remain valid for its full stated term.
- b) The warranties shall be applicable for the supplied equipment in the deployed operating environment and under the operating conditions as specified.
- c) All OEM warranties shall be transferred to Eskom, and those exceeding the base warranty shall remain valid until expiry.
- d) The Contractor shall be responsible for tracking, managing, and administering all OEM warranties and claims on behalf of Eskom.

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- e) The warranty shall cover the full systems, including design, materials, workmanship, and installation, ensuring fitness for purpose and compliance with requirements.
- f) The Contractor shall repair or replace defective items at its own cost, including all transport and logistics.
- g) The Contractor shall clearly define conditions for warranty validity, including maintenance and operational requirements.
- h) Where Eskom performs O&M, the Contractor shall clearly state the operating and maintenance requirements to preserve warranties.
- i) A six-month performance verification period shall apply before final acceptance. The acceptance criteria, data sources, permitted outages, failure classification, defect correction process and restart conditions for the verification period shall be defined in the approved commissioning and performance verification plan.

3.5.8 Operation and Maintenance Period

- a) The Contractor shall provide operation and maintenance services for 12 months commencing on the commercial operation date. These services shall run concurrently with the base warranty and shall include structured transfer of maintenance responsibility to Eskom.
- b) The O&M shall include:
 - 1) Preventative, predictive and breakdown (corrective) maintenance services.
 - 2) Operation support of the standby power system.
 - 3) Performance monitoring in line with requirements.
- c) The scheduled maintenance shall be carried out every as per OEM prescriptions.
- d) The Contractor shall provide corrective maintenance for all failures covered under warranties and guarantees at no cost to Eskom.
- e) The contractor shall ensure compliance with all Eskom site rules and statutory requirements.
- f) All major repairs and replacements shall be agreed with Eskom prior to execution.
- g) The contractor shall use OEM approved or equivalent compatible parts to fully restore system performance and functionality, if the need arises.
- h) The contractor shall develop maintenance base documentation, Task Manuals, Maintenance Engineering Standard and Maintenance Implementation Standard in compliance with Eskom standards and formats.

3.6 Contractor Responsibilities

- a) The Contractor shall be responsible for the assessment, design, implementation and testing of the replacement systems, ensuring compliance with Eskom standards, safety regulations, and industry best practices. The key responsibilities include, but are not limited to, the following:

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3.6.1 Reticulation Assessment

- a) Assess the current system reticulations at both sites, including the development of accurate drawings of the existing configuration to facilitate understanding of the systems to be replaced. The reticulation drawings and associated report shall be submitted to Eskom, and subsequent procedures shall be agreed upon based on the findings.

3.6.2 Engineering Design and System Specification

- a) Develop a detailed engineering design for the replacement of UPSs, including UPS Distribution Boards, rectifiers, and associated wiring for both the NMC and Dx IT Data Centre.
- b) Design and specify the new standby generators for both NMC and It Data centre, ensuring full compliance with relevant international and Eskom standards, requirements, and applicable regulatory guidelines.

3.6.3 Documentation and Coordination

- a) All documentation developed as part of this project shall comply with Eskom standards in terms of, but not limited to, requirements, formatting and file types.
- b) Provide comprehensive documentation, including schematics, technical specifications, installation guidelines, maintenance scope, and other relevant engineering documentation for the proposed replacement systems.
- c) Provide and maintain the maintenance base and design base documentation for the standby power system, including design assumptions, operating criteria, maintenance philosophy, inspection and testing requirements, reliability considerations, and lifecycle support requirements.
- d) Maintain close coordination with Eskom's management and technical teams throughout the assessments, design, procurement, and implementation phases to ensure alignment with operational requirements and standards.
- e) Check sheets shall be supplied for minor inspections as well as major inspections with the applicable maintenance frequencies specified.
- f) Handover Pack: The Contractor shall provide a comprehensive handover pack, in both electronic and editable formats, containing all information required for the long-term management of the standby power system.
 - 1) Technology & Engineering: The approved designs, as-built drawings, test and commissioning reports, compliance certificates, asset information, and warranties.
 - 2) Gauteng Operating Unit: Operating procedures, single-line diagrams, training records, and fault response procedure.
 - 3) Eskom Real Estate: Building layouts, equipment layouts, civil modifications, certificates, and maintenance requirements.
 - 4) Maintenance Personnel: Maintenance manuals, preventive maintenance schedules, spare parts lists, troubleshooting guides, and OEM documentation.

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3.6.4 Compliance and Safety

- a) Ensure that all designs, installations, and replacements adhere to industry best practices, Eskom's operational standards, and all relevant safety regulations.

4. Acceptance

This document has been seen and accepted by:

Full Name and surname	Designation
Thomas Jacobs	Chief Engineer: Standby Power, Energy Storage Systems
Kith Maitisa	Middle Manager: Real Estate
Phumzile Mlangeni	Manager: Complex Projects
Rudi Jacobs	Manager: Network Engineering and Design

5. Revisions

Date	Rev.	Compiler	Remarks
September 2026	1	F Thahale	Original issue.

6. Development team

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

- Fhatuwani Thahale
- Kwandile Malima
- Nthule Mohlala

7. Acknowledgements

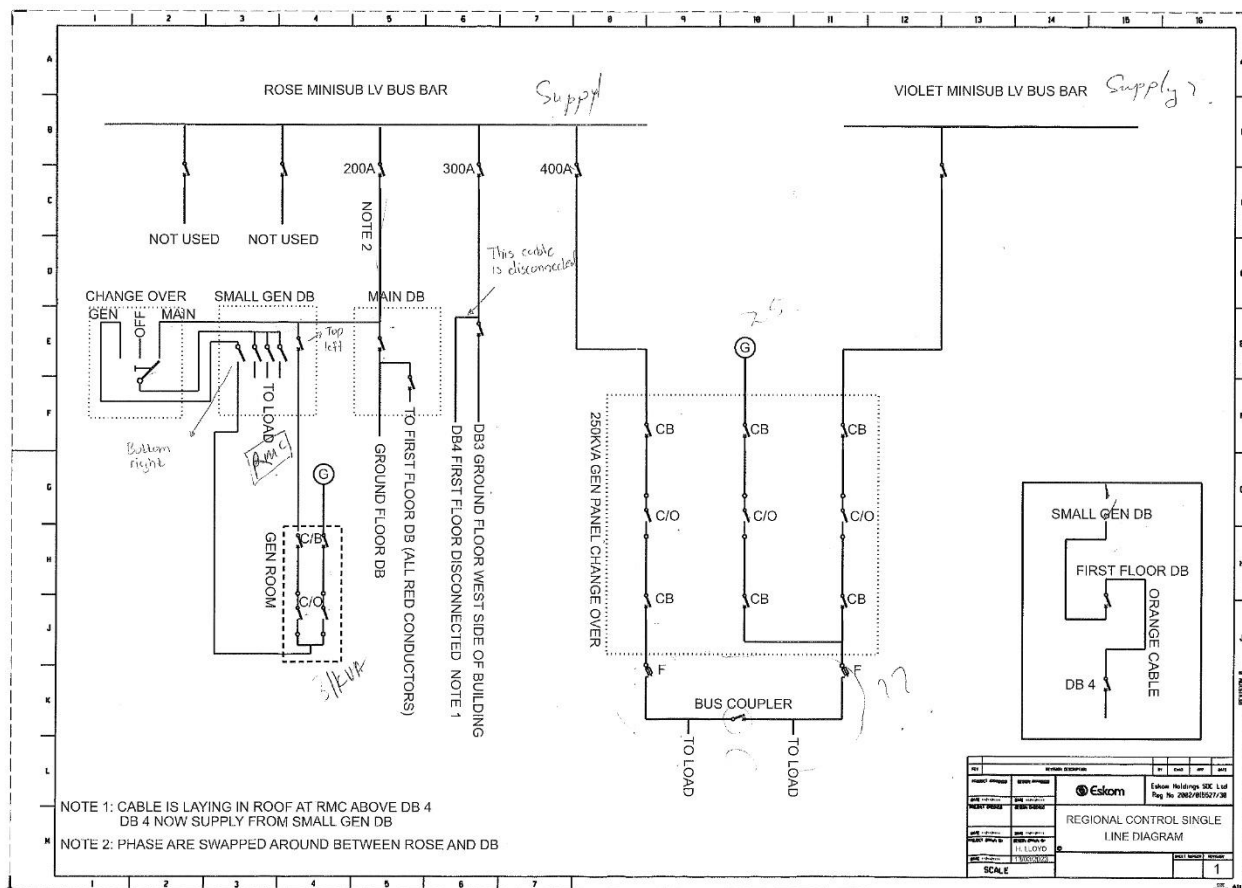
- Welman van Niekerk
- Herbert Lloyd

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Appendix A – NMC

The NMC standby power system equipment:

Figure A.1: NMC building AC supply from minisubs



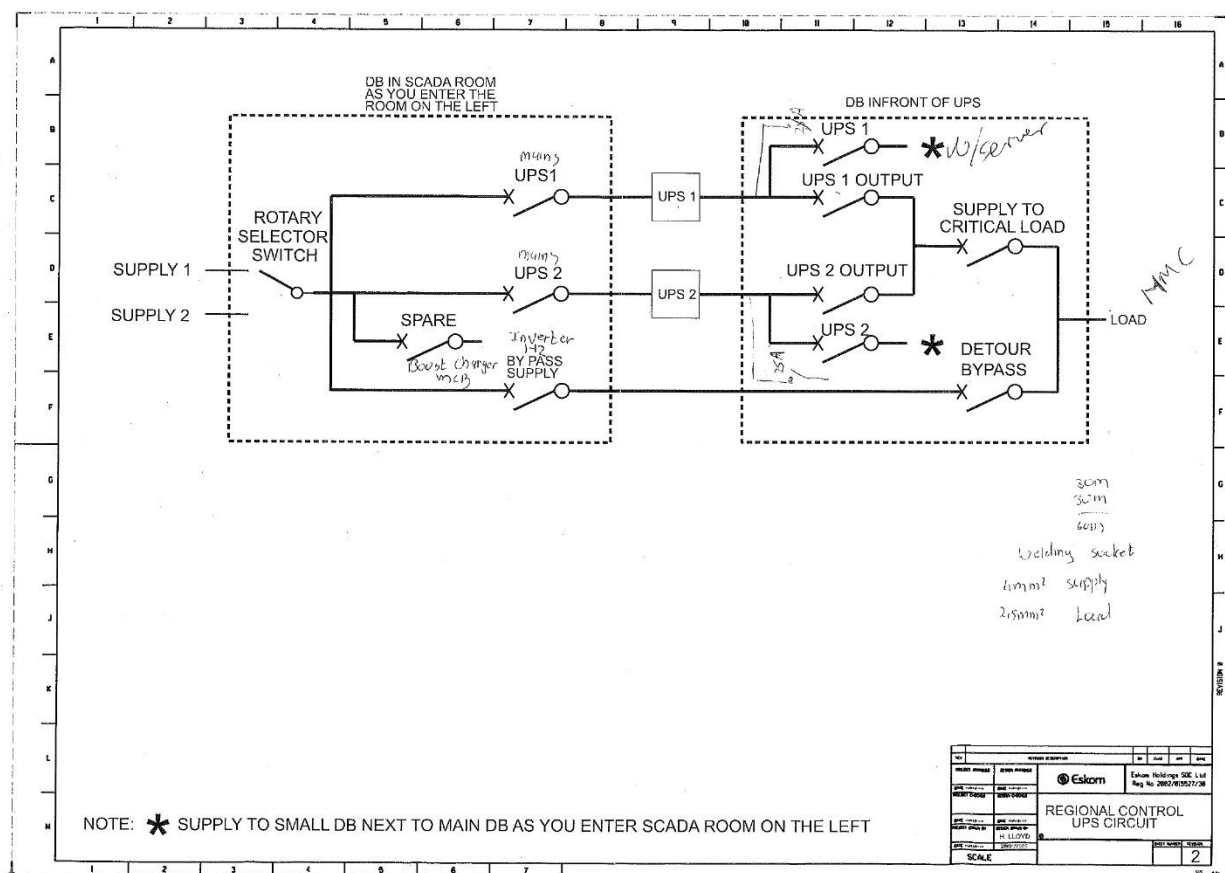
The reticulation of the NMC building from the supply point is illustrated in the diagram above. It should be noted that the diagram is not an original as-built drawing but was developed based on the observed main reticulation system within the building. As such, certain distribution boards, cable routes, protection devices, feeders, changeover arrangements, or associated equipment may not be fully reflected. The contractor shall therefore conduct a detailed reticulation assessment of the NMC building to verify the actual supply arrangement, load distribution, cable sizes, breaker ratings, labelling, earthing arrangement, protection coordination, and condition of the existing electrical infrastructure.

The diagram indicates that the building is supplied via the Rose and Violet minisubs. At present, the Rose minisub supplies the entire building, while the Violet minisub supply is connected to the 250 kVA generator changeover panel. The changeover panel is normally connected to the 400 A supply from the Rose minisub. The status, rating, availability, and intended operating philosophy of the Violet minisub supply shall be verified to determine whether it can be used as an alternative or redundant incoming supply.

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The 31.25 kVA generator supplies the RMC office load, while the 250 kVA generator supplies the UPS load. The other loads supplied by the 250 kVA generator are currently unknown and shall be identified during the detailed reticulation assessment. The contractor shall confirm the connected load profile, segregation between interruptible and uninterruptible loads, generator loading, changeover operation, and downstream distribution paths. All distribution boards supplying interruptible loads on the ground floor shall be connected to ESP DB 1, while distribution boards supplying interruptible loads on the first floor shall be connected to ESP DB 2. The final arrangement shall ensure clear separation of critical UPS-backed loads, generator-backed loads which may include normal interruptible loads, with adequate protection, labelling, maintainability, and operational flexibility.

Figure A.1: NMC building UPS configuration



The UPS configuration is illustrated in the diagram above. The installation comprises two UPS units connected in parallel, allowing load sharing and improved system availability for the connected critical loads. Each UPS is equipped with a dedicated battery bank to provide ride-through support during loss of normal supply until standby generator supply is available.

The UPS system is supplied from the 250 kVA generator changeover panel, with the downstream supply distribution board located in the SCADA room. The bypass supply is provided from the UPS SCADA Room DB, while the detour bypass is in the UPS Room DB, together with the SCADA and NMC load circuit breakers. The contractor shall verify the UPS reticulation, bypass arrangements,

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breaker ratings, cable routes, battery autonomy, and actual connected loads during the detailed site assessment.

Figure A.2: NMC supply minisubs

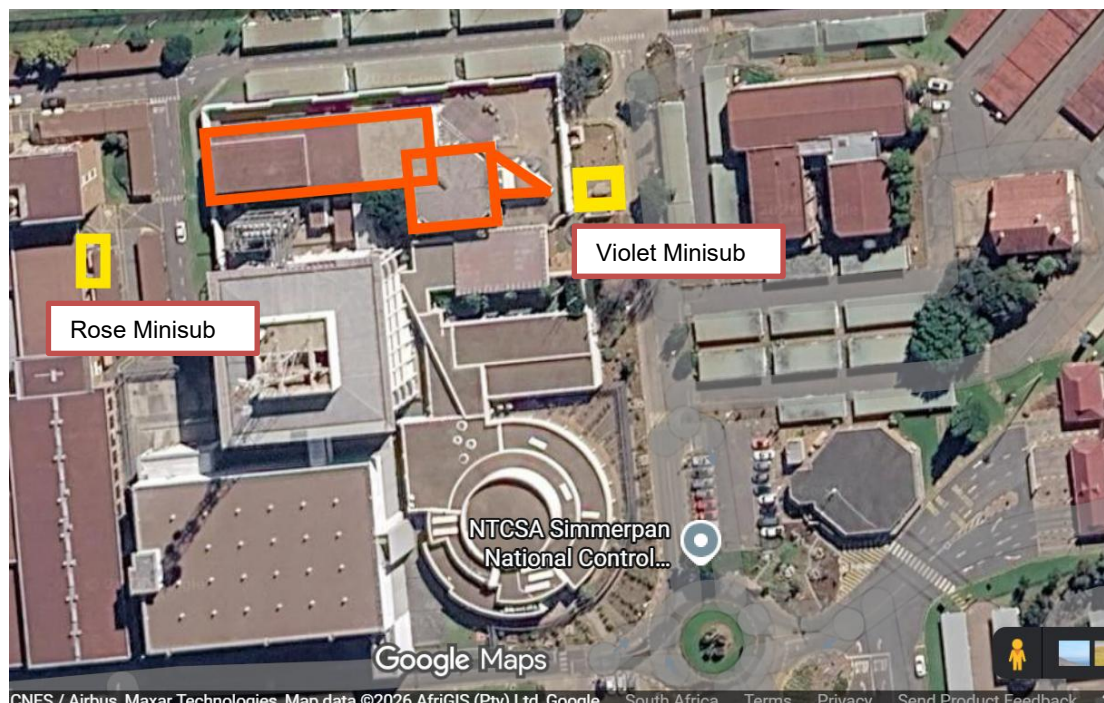
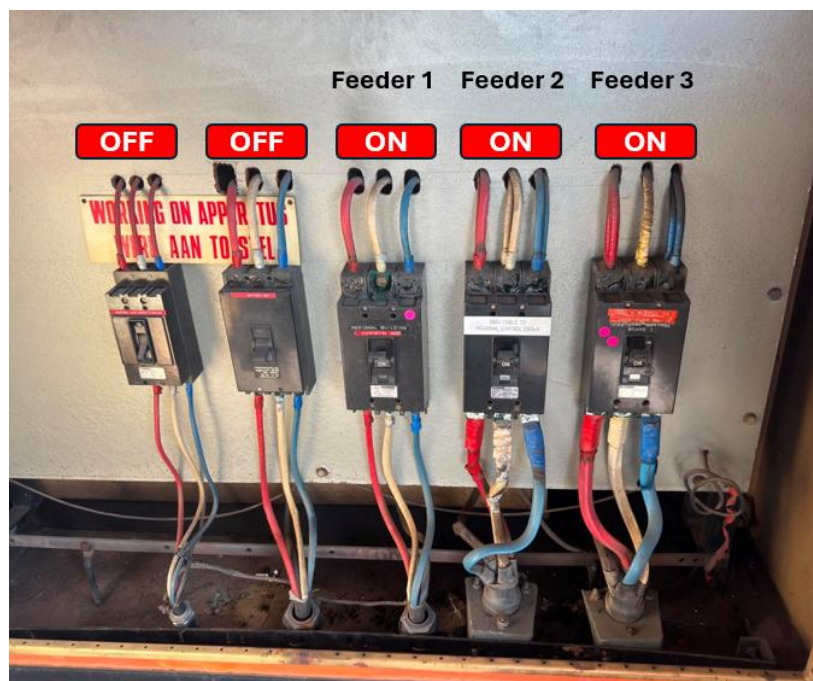


Figure A.4: Rose Minisub



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Table A.1: Dx NMC supply minisub

Rose loading	R phase (A)	W phase (A)	B phase (A)	
Feeder 1 (Clamp)	16	15	34	
Feeder 2 (Clamp)	3	1.3	5	
Feeder 3 (DG) (Clamp)	59	67	57	This feeder is connected to the bigger Diesel Generator
Total	78	83.3	96	Unknown if all loads were on at the time (13:39 Afternoon)

I. Calculating the total demand of the NMC building

Using the average current $I_{avg} = (78 + 83.3 + 96) / 3 = 85.77 \text{ A}$

But to ensure the system can carry the worst-case loading, use the highest measured phase current:

$$I = 96 \text{ A}$$

Assuming:

- Add **10% contingency**
- 400 V three-phase
- **pf = 0.9**

Apparent power: $S = \sqrt{3} \times 400 \times 96 \times 1.1 = 73.16 \text{ kVA}$

Real power: $P = 73.16 \times 0.9 = 65.85 \text{ kW}$

So based on the highest phase: **Measured demand $\approx$ 74 kVA (66 kW)**

II. Calculating the NMC building Generator

Assuming:

- **25% future growth**
- **pf = 0.8 lagging** (From the standard)

With 74 kVA calculated building demand then: $74 \times 1.25 = 92.5 \text{ kVA}$

The generator should be a minimum of **100 kVA**, but with a power factor of 0.8, it gives **80 kW** which will be loaded at **83%** (using 66 kW).

To be safe, design for the loading of below **80%**, then a **minimum of 125 KVA Diesel** Generator shall be installed. It will be **66%** loading at 66 kW demand

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Figure A.4: NMC battery room configuration.

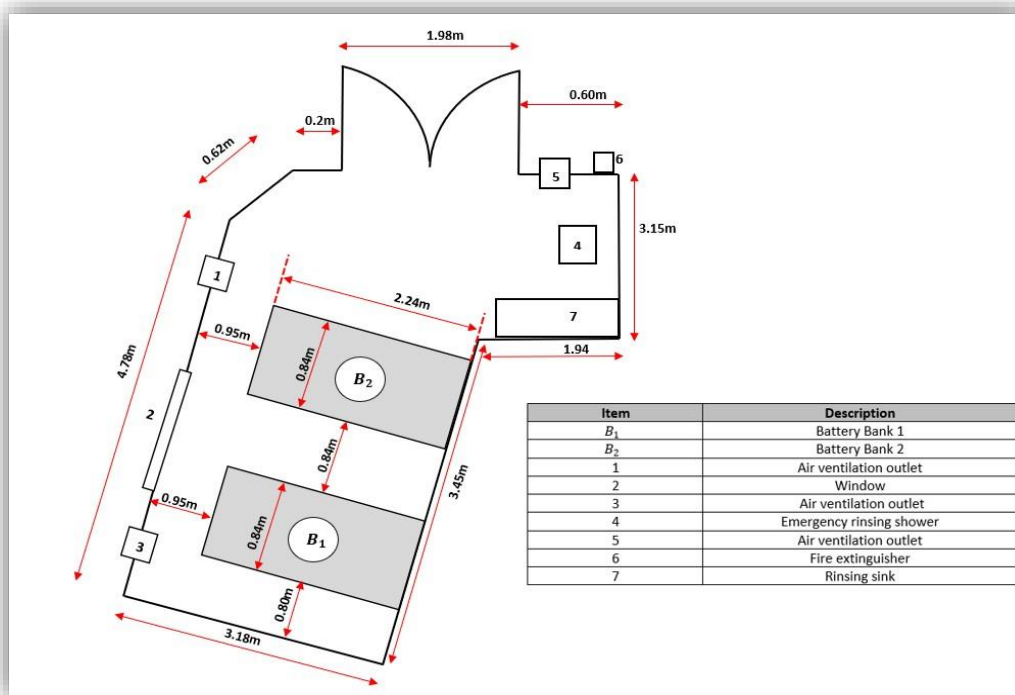
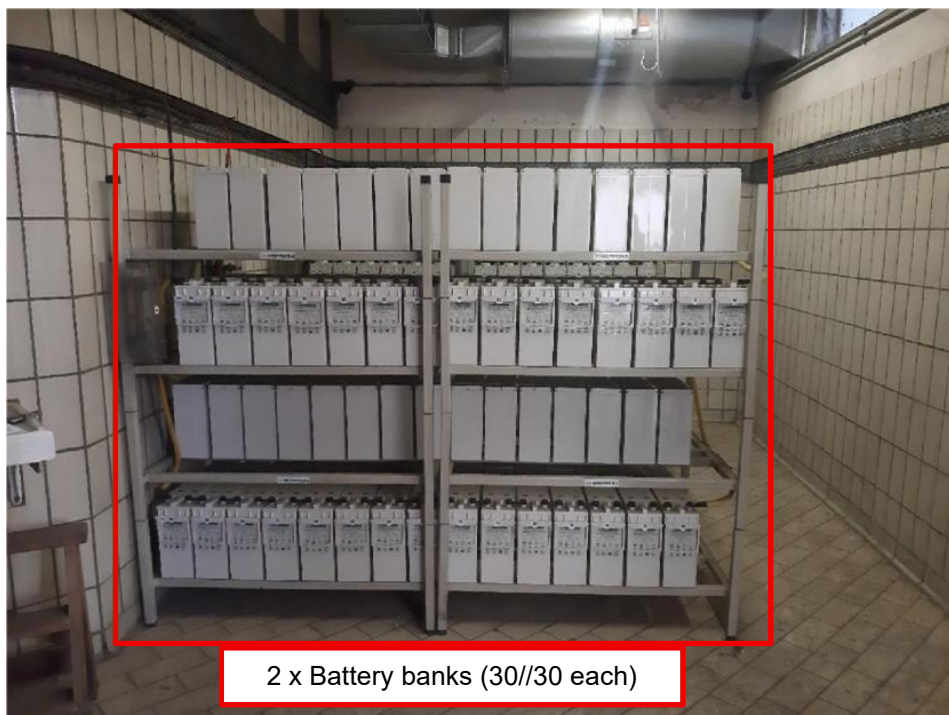


Figure A.5: NMC Battery Banks



The batteries installed at the NMC UPS battery room are the Hoppecke VRLA VR-X-FT 12-170. They are configured in a 30 series paralleled by another 30 series (30//30).

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Table A.2: Present Battery Size per UPS

Matric	Calculation Formula	Total System Value
System Voltage	30 Batteries × 12 V	360 V
Amp-Hour Capacity	2 Strings × 170 Ah	340 Ah
Total Energy Storage	(360 V × 340 Ah) ÷ 1 000	122.4 kWh
Total Battery Count	30 Series × 2 Parallel	60 units

Recorders were put at the output of each UPS in the UPS DB. The two UPS are paralleled and supplying to a common bus, supplying the Network Management Centre office and some servers in the server room. The recording was taken over a period of 24 hours per UPS at 15 minutes intervals. Only the highest current recordings are recorded in the table below. And to get the most accurate demand/loading, the highest current of the phase will be use instead of the average.

Table A.3: NMC UPS load recordings

NMC office supply	R phase (A)	W phase (A)	B phase (A)
UPS A (Recorder)	14.1	23.9	17.4
UPS B (Recorder)	16.4	27.2	19.7
Total	37.5	58.1	42.1

III. Calculating the new UPS sizes

The limiting phase is:

$$I_{max} = 58.1A$$

Assuming a standard three-phase UPS output voltage of **400 V L-L**:

$$S = \sqrt{3} \times V \times I$$

$$S = \sqrt{3} \times 400 \times 58.1$$

$$S = 40.25 \text{ kVA}$$

To be safe, assume **pf = 1**, which gives **P = 40.25 kW**

The Resource Management Centre (RMC) offices are presently not connected to the UPS, but they are connected to the small Diesel Generator. This load must then be transferred to the new UPS configuration, and as a result the RMC office loading is shown in the table below. The loading was taken via a current probe during office hours, at around 14:00 pm.

Table A.4: RMC loadings

	R phase (A)	W phase (A)	B phase (A)
Resource Management Centre (Clamp)	7	7	5

The highest current is 7 A and shall be used for calculating the total demand.

Assuming:

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- **pf = 1**
- 400 V three-phase
- Add **10%** redundancy

$$S = \sqrt{3} \times V \times I$$
$$S = \sqrt{3} \times 400 \times 7 \times 1.1 = 5.33 \text{ kVA}$$

The real power is **5.33 kW**

The following are the loads that are identified as uninterruptable which should be connected to the new standby generator and NMC UPS:

1. Loads under the current UPS

- Server/SCADA room (Ground Floor)
- Network Management Centre office (1st Floor)

2. Loads under the small Gen (RMC connected)

- Resource Management Centre office (1st Floor)

3. Unknown loads

- Security Monitoring Room (1st Floor)
- SCADA support office (Ground Floor)

The unknown loads are office-based loads like plugs, lights and monitors and as such they are assumed to be **25%** of the total new UPS load.

New UPS Loads: **NMC + RMC + 25% = (40.25 + 5.33) x 1.25 = 56.98 kW**

And future growth of 20% then **56.98 x 1.20 = 68.38 kW**

Modern UPS systems can achieve an output power factor close to unity. A conservative output power factor of 0.95 has therefore been applied for preliminary sizing:

$$S = \frac{P}{pf} = \frac{68.38}{0.95} = 71.98 \text{ kVA}$$

Then a minimum of **2(N+1) redundancy UPS of 80 kVA**

IV. Calculating the battery size

The battery must give an autonomy of 4 hours per battery bank. When sizing, the future growth of 20% shall

be considered, taking the space constraints into consideration. So, **56.98 kW**

Then: **4 hr x 56.98 kW = 227.92 kWh**

230 kWh is the minimum usable energy requirement per battery bank, based on the calculated four-hour duty rounded upward from 227.92 kWh.

For LFP.

Assuming:

- Required usable energy = 240 kWh
- Maximum DoD = 90%

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- End-of-life capacity = 80%

$$= \frac{240}{0.9 \times 0.8}$$

$$= 316.56 \text{ kWh}$$

Therefore:

- ~230 kWh = minimum required usable energy
- ~320 kWh = minimum installed battery capacity required to provide approximately 230 kWh usable energy at 90% maximum depth of discharge and 80% end-of-life capacity

For space constrain, 480 Vdc bus shall be utilised.

Table A.5: Minimum sizes at the NMC

UPS	Diesel Generator	Battery
80 kVA	125 kVA	320 kWh
80 kVA		320 kWh

Figure A.6: NMC battery room sink.



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Figure A.7: NMC Charger for DC Loads



The installed DC power system comprises two 48 V, 1 kW CXRC rectifier/charger modules operating in parallel, providing a total installed charger capacity of 2 kW. The associated battery bank consists of Alcad CN119-2 nickel-cadmium cells configured as a 38//38 arrangement, resulting in an installed battery capacity of 238 Ah. Based on the measured operating conditions of 53.46 V DC and 18.53 A load current (including the floating current), the connected DC load is approximately 991 W.

This represents approximately 49.5% utilisation of the installed 2 kW charger capacity, leaving approximately 1.01 kW spare charger capacity. The corresponding installed battery energy storage is approximately 10.85 kWh (using 1.2V x 38 batteries x 2 x 119Ah), providing a theoretical autonomy of approximately 11 hours at the measured load. The batteries were made in May 2010, but the installation data is unknown. They are currently 16 years old.

Calculating the DC battery size:

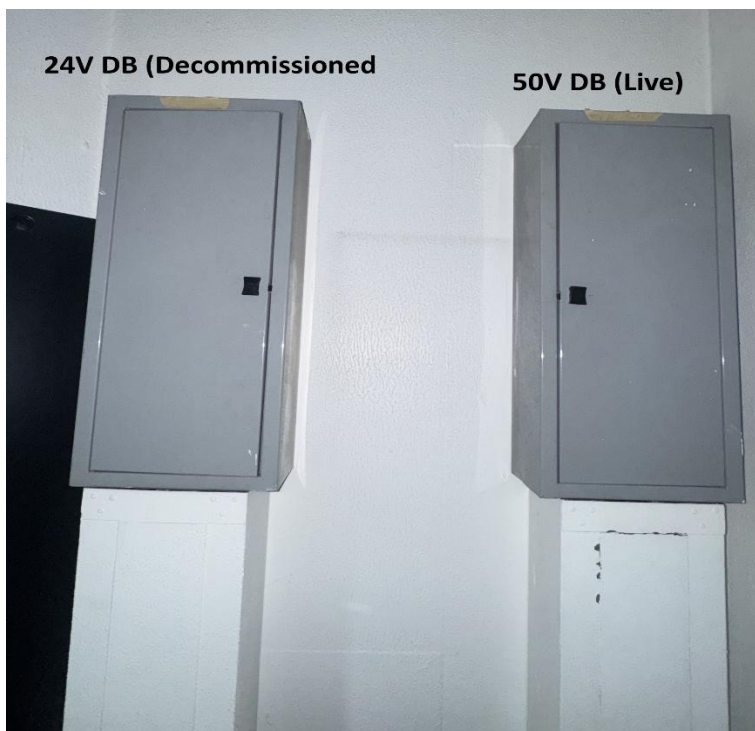
- a) The current DC load is approximately **991 W** at a nominal voltage of 50 **Vdc**.
- b) Load current is at 19.82 A, approximately **20 A**, and for a minimum autonomy of **4 hours** it gives **80 Ah**. Then considering that the growth of only **10%** because of space constrain, an 88 Ah battery is warranted.
- c) But the 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. Then a **minimum of 110 Ah shall be installed**.
- d) A dual redundant **48V, 2 kW 40 A** chargers are required.

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Figure A.8: NMC Charger battery bank (38//38)



Figure A.9: NMC DC DBs

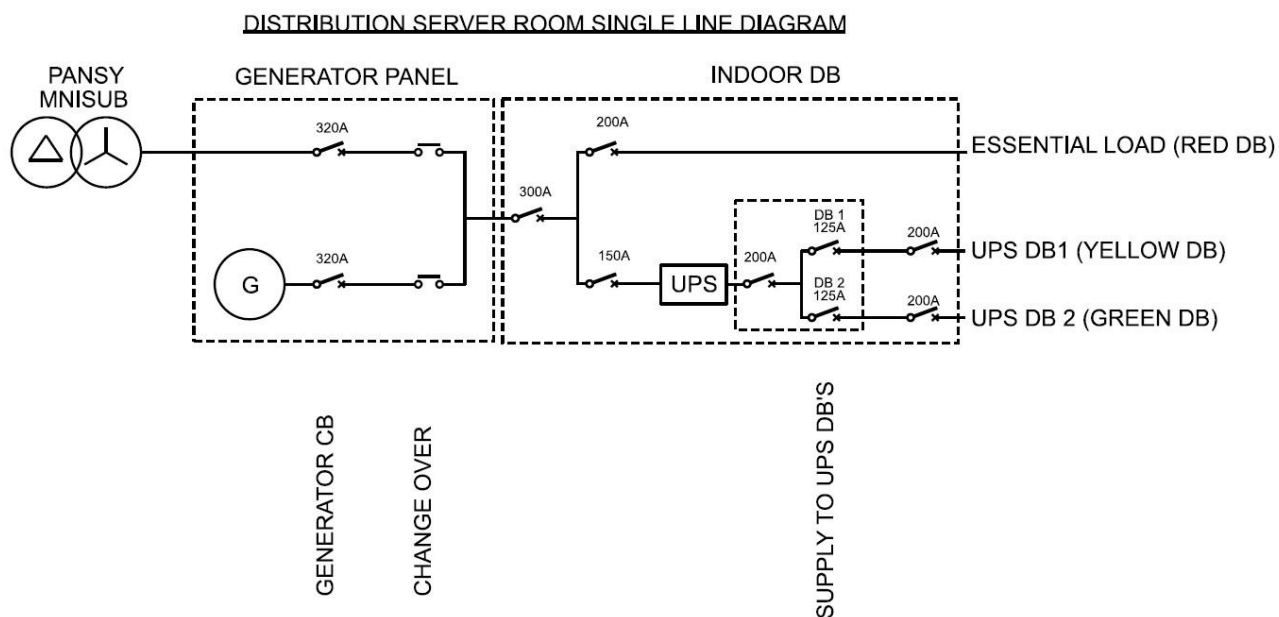


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Appendix B – IT Data Centre

The IT Data Centre standby power equipment:

Figure B.1: Dx IT Data Centre AC Supply Reticulation



The existing Dx IT Data Centre reticulation is not supported by a verified as-built single-line diagram. The indicative drawing was developed from visible equipment and may omit critical information. The Contractor shall complete a detailed reticulation assessment and issue verified existing-system drawings before commencing the detailed design.

There is only one AC supply to the Dx It Data Centre with a single generator and UPS (together with batteries) as standby power equipment. The generator and the changeover are located outside the room, and the incomer is split between the uninterruptable and interruptible loads in the red distribution board.

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Figure B.2: It Data Centre Room Configuration

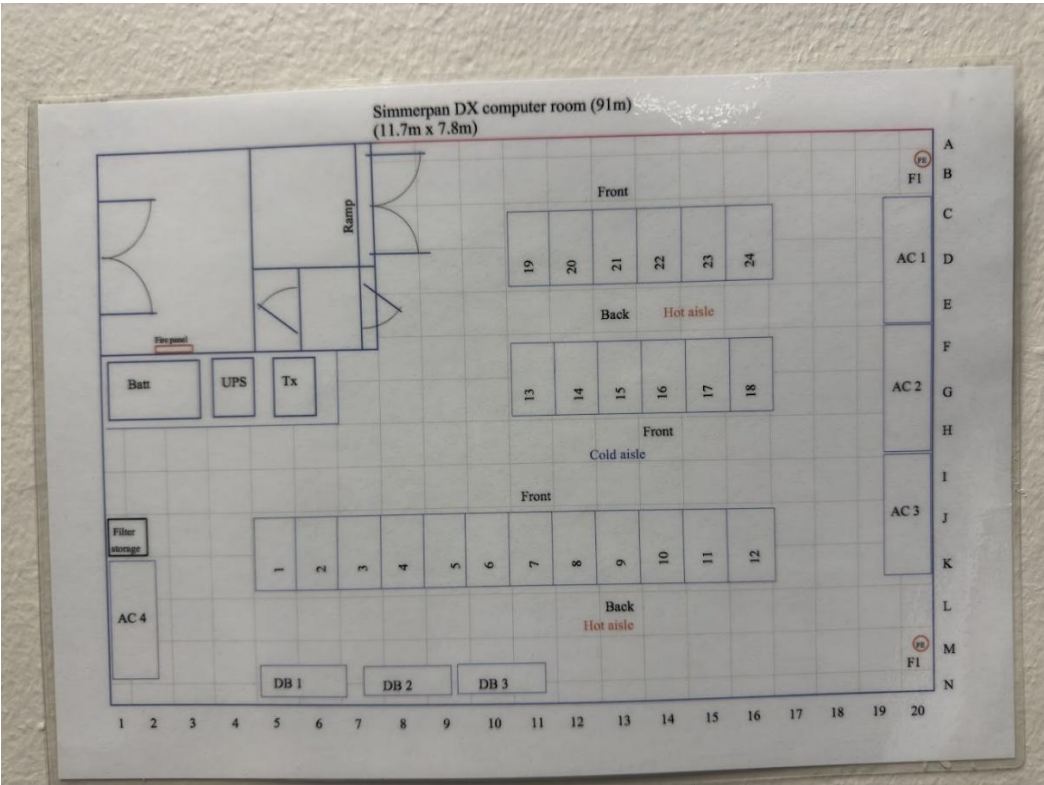
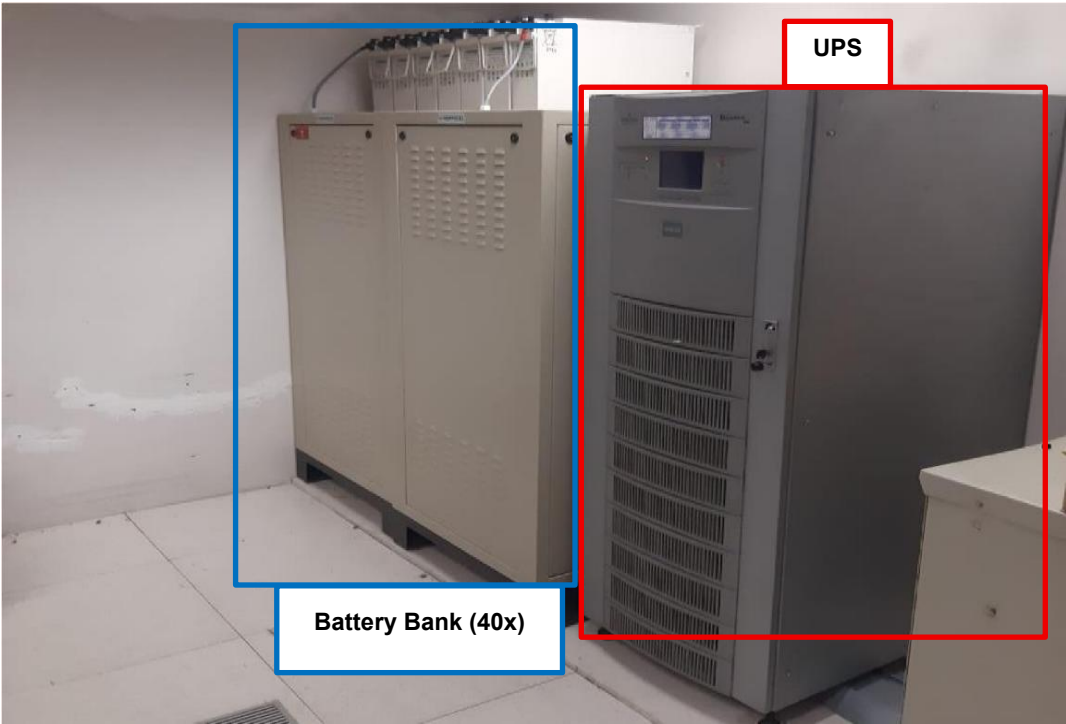


Figure B.3: IT Data Centre Equipment



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The UPS is currently supplying approximately:

- i. 18.1 kW real load
- ii. 18.9 kVA apparent load
- iii. 5.0 kVAR reactive load

This corresponds to approximately 24% loading of the 80 kVA UPS. The load is significantly unbalanced, with Phase L2 carrying 8.9 kW, Phase L1 carrying 6.4 kW, and Phase L3 carrying only 2.8 kW.

The batteries installed at the NMC UPS battery room are the Hoppecke VRLA VR-X-FT 12-170. They are configured in a 40 series bank.

Table B.1: Present Dx IT Data Centre UPS battery size

Matric	Calculation Formula	Total System Value
System Voltage	40 Batteries × 12 V	480 V
Amp-Hour Capacity	1 Strings × 170 Ah	170 Ah
Total Energy Storage	(480 V × 170 Ah) ÷ 1 000	81.6 kWh
Total Battery Count	40 Series × 1 Parallel	40 units

Recorders were put at the output of the UPS in the UPS DB. The UPS is supplying server in the Dx IT Data Centre room. The recording was taken over a period of 24 hours per UPS at 15 minutes intervals. Only the highest current recordings are recorded in the table below. And to get the most accurate demand/loading, the highest current of the phase will be use instead of the average. The DG/Supply loading was taken via a current probe during office hours, at around 14:30 pm

Table B.2: Dx IT Data Centre supply and UPS loading

Dx Server room	R phase (A)	W phase (A)	B phase (A)
DG /Supply loading (Clamp)	78.0	87.0	77.0
UPS Output (Recorder)	52.1	40.4	39.1

I. Calculating the total demand of the IT Data Centre building:

Using the average current $I_{avg} = (78 + 87 + 77) / 3 = 80.67 \text{ A}$

But to ensure the system can carry the worst-case loading, use the highest measured phase current:

$$I = 87 \text{ A}$$

Assuming:

- Add **10% contingency**
- 400 V three-phase
- **pf = 0.9**

Apparent power:

$$S = \sqrt{3} \times 400 \times 87 \times 1.1 = 66.30 \text{ kVA}$$

Real power:

$$P = 66.3 \times 0.9 = 59.67 \text{ kW}$$

CONTROLLED DISCLOSURE

So based on the highest phase: **Measured demand $\approx$ 67 kVA (60 kW)**

II. Calculating the IT Data Centre building Generator

Assuming:

- **25%** future growth
- **pf = 0.8 lagging** (From the standard)

With 74 kVA calculated building demand then: $67 \times 1.25 = 83.75$ kVA

The generator should be **a minimum of 100 kVA**, but with a power factor of 0.8, it gives **80 kW** which will be loaded at **75%** (using 60 kW).

III. Calculating the new UPS sizes

The limiting phase is:

$$I_{max} = 52.1 \text{ A}$$

Assuming a standard three-phase UPS output voltage of **400 V L-L**:

$$\begin{aligned} S &= \sqrt{3} \times V \times I \\ S &= \sqrt{3} \times 400 \times 52.1 \\ S &= 36.1 \text{ kVA} \end{aligned}$$

To be safe, assume **pf = 1**, which gives **P = 36.1 kW**

And future growth of 20% then **36.1 x 1.20 = 43.32 kW**

Modern UPS systems can achieve an output power factor close to unity. A conservative output power factor of 0.95 has therefore been applied for preliminary sizing:

$$S = \frac{P}{\text{pf}} = \frac{43.32}{0.95} = 45.59 \text{ kVA}$$

Then **a minimum of 2(N+1) redundancy UPS of 60 kVA**

IV. Calculating the battery size

The battery must give an autonomy of 4 hours per battery bank. When sizing, the future growth of 25% will not

be considered, because of space and capital constrains. So, **36.1 kW**

Then: 4 hr x 36.1 kW = 144.4 kWh

144 kWh is the usable energy requirement per battery bank.

For LFP.

Assuming:

- Required energy = 144.4 kWh
- Maximum DoD = 90%
- End-of-life capacity = 80%

$$\begin{aligned} &= \frac{144.4}{0.9 \times 0.8} \\ &= 200.5 \text{ kWh} \end{aligned}$$

CONTROLLED DISCLOSURE

Therefore:

- **~144 kWh** = required usable energy
- **~200 kWh** = installed battery capacity required to guarantee 144 kWh at end of life

For space constrain, 480 Vdc bus shall be utilised.

Table B.3: Minimum sizes at the Dx Control Centre

UPS	Diesel Generator	Battery
60 kVA	100 kVA	200 kWh
60 kVA		200 kWh

CONTROLLED DISCLOSURE