ELEMENT Consulting Engineers
A FIFTH DIMENSION TO ENGINEERING

PRELIMINARY DESIGN REPORT

PV SOLAR PLANTS & BATTERY ENERGY STORAGE SYSTEMS FOR HARTENBOS WASTEWATER TREATMENT WORKS

OUR REFERENCE NO. 2300431

05 SEPTEMBER 2023

Mossel Bay Municipality
101 Marsh Street,
Mossel Bay,
6500
Tel: +27 (44) 606 5000
Fax: +27 (44) 606 5062

MOSSELBAAI
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Explore Endless Horizons!

George Office
George, Western Cape
Tel: +27 44 884 1138
Fax: +27 44 884 1185
82 Victoria Street
George, 6530

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Compiled By:	………………………….. Jako Fourie, Pr.Eng	………………….. Date
Reviewed By:	…………………………… Hannes Lourens Pr.Eng	………………….. Date

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0	First Submission	05 September 2023	J Fourie

DISTRIBUTION LIST

Name	Company	Email	Tel
P Harmse	Mossel Bay Municipality	pharmse@mosselbay.gov.za	(044) 606-5000
S Naidoo	Mossel Bay Municipality	dnaidoo@mosselbay.gov.za	(044) 606-5000
R van Zyl	Mossel Bay Municipality	rvanzyl@mosselbay.gov.za	(044) 606-5000
M Olivier	Mossel Bay Municipality	molivier@mosselbay.gov.za	(044) 606-5000

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CONTENTS

EXECUTIVE SUMMARY IV

1 INTRODUCTION 1

1.1 Background 1

1.2 Objective 1

1.3 Consultant's Terms of Reference 2

1.4 Inception meeting 3

1.5 Project Budget 3

1.6 Project Schedule 3

1.7 Liaison 3

2 EXISTING SITE LAYOUT 4

2.1 Background 4

2.2 Location & Access 4

2.3 Site Conditions 6

3 ELECTRICAL NETWORK ASSESSMENT 8

3.1 Network Configuration (Existing) 8

3.2 Load Profile Data 9

4 PRELIMINARY DESIGN: ELECTRICAL 11

4.1 Specific Design Considerations 11

4.2 Proposed System Layout 11

4.3 Proposed Network Re-configuration 13

4.4 Proposed Site Development Plan 14

4.5 Proposed System Operation 15

4.6 Software Simulations 18

4.7 Proposed PV Solar Plant 18

4.8 Proposed Battery Energy Storage System 23

4.9 Proposed Standby Generators 23

4.10 Specific Equipment Requirements 24

4.11 Energy Monitoring and Control System 33

4.12 Weather Station 36

4.13 MV Cables (AC) 37

4.14 LV Cables (AC) 37

4.15 LV Cables (DC) 37

4.16 Earthing & Bonding 38

4.17 Surge & Lightning Protection 39

5 PRELIMINARY DESIGN: CIVIL 40

5.1 Background 40

5.2 Terms of reference 40

5.3 Site Assessment 40

5.4 Topographical Survey 41

5.5 Geotechnical Investigation 43

5.6 Soil Thermal Resistivity Measurements 44

5.7 Soil Resistivity Measurements 45

5.8 Environmental Impact Assessment (EIA) 45

5.9 Earthworks 46

5.10 Water48

5.11 Sewer 49

5.12 Roads and access 50

5.13 Traffic Impact Statement 51

5.14 Stormwater management plan 51

5.15 Foundations and Structures 57

5.16 Solid Waste 59

5.17 Security Fencing 59

6 BUDGET COST ESTIMATE 60

7 WAY FORWARD 63

7.1 Detail Design 63

7.2 Procurement 63

7.3 Implementation 63

7.4 Project Completion and Commissioning 64

8 CONCLUSION & RECOMMENDATIONS 65

8.1 Conclusions 65

8.2 Recommendations 66

9 ADDENDA 68

9.1 Addendum 1 – Proposed Site Development Plan 68

9.2 Addendum 2 – Proposed Single Line Diagram 68

9.3 Addendum 3 – Proposed Network Configuration Diagram 68

EXECUTIVE SUMMARY

The Mossel Bay Municipality (MBM) strives to be a sustainable, world-class municipality that is caring and committed to creating a better life for all its people, which cannot be achieved without a clear set of policies and strategies for sustainable growth and development. The core role of energy within communities, in terms of socio-economic development and environmental sustainability, is being increasingly recognised by local authorities. Energy plays a vital role in providing basic services and meeting basic human needs, such as jobs, food, running water, sanitation, education and health services. Addressing these issues, inevitably involves an increase in the level of energy services.

MBM aims to improve quality of life within its supply area by improving energy efficiency, availability and reliability. MBM is therefore embarking on a journey of implementing embedded generation (own generation) and energy storage alternatives and thereby contributing to sustainable growth and development in the area through reliable and cost-effective energy provision within its area of jurisdiction.

Considering the current problems experienced within Eskom in terms of availability and reliability of electrical energy supply, Mossel Bay Municipality recognises the need for planning more sustainable approaches to their energy production and distribution, to promote economic development and meet social needs while at the same time reducing local and global environmental impacts.

For this reason, Element Consulting Engineers (ECE) have been appointed by MBM as Civil and Electrical Consulting Engineers for the implementation of embedded generation and/or storage options on some of the most critical infrastructure in the town of Mossel Bay and the surrounding areas. A number of key strategic plants (such as water and wastewater treatment plants) have been identified as best possible options for the implementation of these plants.

As part of a high-level feasibility study and cost estimate that was done on various critical facilities within the Mossel Bay Municipal area of jurisdiction, the following plants were identified as best possible candidates for the implementation of PV Solar plants with sufficient battery energy storage capacity:

1. Hartenbos Wastewater Treatment Works
2. Grootbrak Wastewater Treatment Works
3. Kleinbrak Water Treatment Works

To ensure the timely implementation of these projects, it was decided to divide the project into different phases, which are mainly driven by the availability of land for free-field solar installations with the least amount of environmental impact. For this reason, it was decided by the Mossel Bay Municipality to implement the renewable energy strategies at the abovementioned plants in different phases, spread over a 3-year period. The project staging will be as follows:

- Phase 1: Hartenbos Wastewater Treatment Works   Financial Year 2023/2024
- Phase 2: Grootbrak Wastewater Treatment Works   Financial Year 2024/2025
- Phase 3: Kleinbrak Water Treatment Works   Financial Year 2025/2026

Due to the variations in plant configurations and load profiles, each of these will be treated as separate projects. This report only therefore only covers the Preliminary Design work associated with Phase 1 of the project for the Hartenbos Wastewater Treatment Works.

From the load profile analysis done for the Hartenbos WWTW, it was determined that the average energy consumption for the plant is 925 kWh and the maximum demand recorded for any specific half-hour period was 1152kVA. These values were used in the calculations for the sizing of the PV solar plant, the inverters as well as the battery storage capacity.

The aim of the proposed solution was to design a hybrid system that will be grid-tied under normal operating conditions, providing battery backup as first line of support when the grid supply is interrupted. Furthermore, standby diesel generators will also be incorporated into the system design to serve as a final level of support to the load when the batteries are depleted, and the grid supply (or PV solar generation) remains unavailable.

In summary, it can be concluded that the proposed hybrid system will consist of the following:

a. 1760 kVA grid-tied, free-field solar PV installation (requiring ± 20 000m^2 installation area).
b. Installation of 3692 x 550Wp Mono-crystalline Solar Panels, which convert the solar radiation into direct current.
c. Fixed tilt ground mounting structures, which supports the PV modules.
d. 5x String inverters, which convert the DC from the solar field to AC.
e. 1x MV Inverter Station (3.2MVA), which collects the AC output from each of the inverters and incorporates a step-up power transformer, which steps the inverter output voltage up to the 11kV network voltage. The inverter station also has integrated 11kV switchgear to connect to the MV network.
f. 4512 kWh Battery Energy Storage System (consisting of 2x 2256kWh batteries in containers).
g. 1x 1.757 MVA Power Conversion System (PCS), which converts the DC battery output to AC power.
h. 1x 1.6 MVA Isolation transformer, which steps the PCS output up to 11kV.
i. 2x 800 kVA Backup Diesel Generators (containerised).
j. 1x 1.6 MVA Step-up transformer, which steps the generator output up to 11kV.
k. 6x 11kV (25kA) AIS switchgear panels, complete with associated protection, metering and control elements, to be housed in a new substation building.
l. 1x 11kV Neutral Earthing Resistor (NER), to be installed on the star-point of the generator step-up transformer's MV winding.

The preliminary design stage programme indicates completion of commissioning and handover for the hybrid plant solution to be on 30 June 2025.

The preliminary design stage cost estimate amounts to R135.99 mil (incl. P&G's, contingencies, escalation, professional fees & VAT).

ACRONYMS

A	Ampere
AAAC	All Aluminium Alloy Conductor
AC	Alternating Current
ADMD	After Diversity Maximum Demand
BESS	Battery Energy Storage System
BIL	Basic Insulation Level
CSP	Concentrated Solar Plant
DG	Distributed Generation
DHI	Diffused Horizontal Irradiation
DOE	Department of Energy
DSM	Demand Side Management
ECE	Element Consulting Engineers
EIA	Environmental Impact Assessment
EG	Embedded Generator
ERA	Electricity Regulation Act
FIT	Feed-in Tariff
GHI	Global Horizontal Irradiation
HV	High Voltage
IPP	Independent Power Producer
IRP	Integrated Resource Plan
kV	Kilovolt
kVA	kilo-Volt Ampere (unit of electrical power)
kW	kilo-Watt (unit of electrical power)
kWp	kilo-Watt peak (the rated peak output of solar PV panels)
LV	Low voltage
MBM	Mossel Bay Municipality
MPa	Mega Pascal
MV	Medium Voltage
MVA	Mega-Volt Amperes (1000 kVA)
NERSA	National Energy Regulator of South Africa
NMD	Notified Maximum Demand
PCS	Power Conversion System
PPA	Power Purchase Agreement
PUC	Point of Utility Connection
PV	Photovoltaic
REIPPP	Renewable Energy Independent Power Producer Programme
RHFC	Regenerative hydrogen fuel cells
RMU	Ring Main Unit
RPP	Renewable Power Producer
SCADA	Supervisory Control and Data Acquisition
SDF	Spatial Development Framework
SS	Substation
SSEG	Small Scale Embedded Generation
THD	Total Harmonic Distortion
UISP	Upgrading of Informal Settlements Plan
UPS	Uninterrupted Power Supply
VRE	Variable Renewable Energy

1 INTRODUCTION

1.1 Background

The Mossel Bay Municipality (MBM) strives to be a sustainable, world-class municipality that is caring and committed to creating a better life for all of its people, which cannot be achieved without a clear set of policies and strategies for sustainable growth and development. The core role of energy within communities, in terms of socio-economic development and environmental sustainability, is being increasingly recognised by local authorities. Energy plays a vital role in providing basic services and meeting basic human needs, such as jobs, food, running water, sanitation, education and health services. Addressing these issues, inevitably involves an increase in the level of energy services.

MBM aims to improve quality of life within its supply area by improving energy efficiency, availability and reliability. MBM is therefore embarking on a journey of implementing embedded generation (own generation) and energy storage alternatives and thereby contributing to sustainable growth and development in the area through reliable and cost-effective energy provision within its area of jurisdiction.

Electricity generation in South Africa is currently primarily undertaken by state-owned power and utilities company Eskom, however increasingly by independent power producers. The transmission of electricity is undertaken by Eskom and electricity distribution (the final delivery of electricity to end users) is currently undertaken by Eskom together with various local municipalities, of which MBM is one.

1.2 Objective

Considering the current problems experienced within Eskom in terms of availability and reliability of electrical energy supply, Mossel Bay Municipality recognises the need for planning more sustainable approaches to their energy production and distribution, to promote economic development and meet social needs while at the same time reducing local and global environmental impacts.

For this reason, Element Consulting Engineers (ECE) have been appointed by MBM as Civil and Electrical Consulting Engineers for the implementation of embedded generation and/or storage options on some of the most critical infrastructure in the town of Mossel Bay and the surrounding areas. A number of key strategic plants (such as water and wastewater treatment plants) have been identified as best possible options for the implementation of these plants.

As part of a high-level feasibility study and cost estimate that was done on various critical facilities within the Mossel Bay Municipal area of jurisdiction, the following plants were identified as best possible candidates for the implementation of PV Solar plants with sufficient battery energy storage capacity:

4. Hartenbos Wastewater Treatment Works
5. Grootbrak Wastewater Treatment Works
6. Kleinbrak Water Treatment Works

To ensure the timely implementation of these projects, it was decided to divide the project into different phases, which are mainly driven by the availability of land for free-field solar installations with the least amount of environmental impact. For this reason, it was decided by the Mossel Bay Municipality to implement the renewable energy strategies at the abovementioned plants in different phases, spread over a 3-year period.

The project staging will be as follows:

- Phase 1: Hartenbos Wastewater Treatment Works Financial Year 2023/2024
- Phase 2: Grootbrak Wastewater Treatment Works Financial Year 2024/2025
- Phase 3: Kleinbrak Water Treatment Works Financial Year 2025/2026

Due to the variations in plant configurations and load profiles, each of these will be treated as separate projects. This report only therefore only covers the Preliminary Design work associated with Phase 1 of the project for the Hartenbos Wastewater Treatment Works.

1.3 Consultant's Terms of Reference

To facilitate the successful implementation of the first phase of this project, the Consultant will in summary be responsible for the following actions (details are presented and discussed later in the report):

a) Obtain load profile data for all metering points for at least six (6) months (year-to-date), which will be used for the sizing of the PV solar facility and the BESS capacity.
b) Site visit to the plant to determine existing equipment positions and possible locations for the renewable energy plant and equipment.
c) Investigate, report and presentation on alternative options with recommendations.
d) Perform Preliminary Design for the preferred option/s, including proposed equipment positions, single line diagrams, solar yield calculations, cost estimates and project implementation schedules.
e) Compilation of Tender documentation in CIDB format including construction specifications for the project.
f) Tender process and evaluation.
g) Review of Detail Design and equipment specifications done by the successful Tenderer.
h) Implementation of the recommended upgrades in accordance with the available funds and other relevant resources, including planning, design, procurement, supervision and facilitating construction of required infrastructure.
i) Quality control and ensure that tests and commissioning comply with contract.
j) Financial control and contractor payment certificates.
k) Provide monthly reporting.
l) Monthly site meetings, site inspections, chairing and keeping minutes.
m) Close out report including as built drawings and documentation.
n) Compliance with Environmental Legislation.

1.4 Inception meeting

An inception meeting was held on 07 June 2023 at 13h00 at the Salt & Copper Restaurant in Hartenbos. The meeting covered all introductory, background, technical, budgetary and programming aspects of the project, all of which will be covered in the following paragraphs.

1.5 Project Budget

The project budget is in the order of R235.4m (based on the Business Plan Report) but will eventually be a function of the preliminary design, detail design and tender processes for the different phases of the project.

The project will also be a multi-year tender with funding spread over three (3) financial years, with an initial allocation as follows:

- 2023/24: R 23.54 mil (10%)
- 2024/25: R 141.2 mil (60%)
- 2025/26: R 70.62 mil (30%)

An updated preliminary design stage budget breakdown is provided later in the report.

1.6 Project Schedule

The project is envisaged to be implemented during the 2023/24, 2024/25 and 2025/26 financial years. A relatively large number of unknowns are still present at this early stage, specifically on the environmental side as well as the type of solutions that might be best suited for the different plant-specific requirements.

A high-level preliminary design stage project schedule is provided later in the report.

1.7 Liaison

During the project mobilization phase, the necessary liaising with the necessary client representatives has been performed to obtain a variety of technical inputs into the project, inclusive of available documentation, billing information, drawings, etc.

2 EXISTING SITE LAYOUT

2.1 Background

The **Hartenbos Wastewater Treatment Works** has been identified as the first critical plant that will be selected for the implementation of a proposed hybrid renewable energy solution, as it provides an ideal scenario due to the following considerations:

- Treatment works has a very constant base load.
- Critical application, requiring standby diesel generation.
- Space around the plant for the installation of renewable energy sources.
- Not within the residential areas.
- Already identified as ideal position for application of renewable energy generation.
- Proposed PV Solar & BESS installation area (5.82ha) available in close proximity to the water treatment works.
- Proposed PV Solar & BESS installation area belongs to the Mossel Bay Municipality and has already been disturbed, which will simplify the EIA process.
- Entire plant area is already fenced and secured, which limits the risk of theft and vandalism.
- All loads being supplied from local (existing) LV switchboards.
- Localised MV supply network, dedicated for the supply of the treatment works, which will require minimal amount of modification to accommodate “islanded” operation.
- Sufficient space within the plant boundaries for the positioning of battery storage containers, standby generators and additional MV switchgear that will be required as part of the renewable energy plant installation.

2.2 Location & Access

The location of the Hartenbos WWTW is indicated in Figure 2-1 below.

As can be seen from this figure, the Hartenbos WWTW site is located directly north of the R102 Main Road and approximately 1.2km north of the village of Hartenbos in the Mossel Bay municipal area. The coordinates of the centre of the works are approximately 34° 6' 24.76"S and 22° 6' 7.59"E.

The area has a moderate climate with rainfall occurring throughout the year with slightly higher rainfall during the summer. The area has a mean annual precipitation in the region of 450 mm per year.

Access to the facility is obtained from the R102 Main Road, via a tarred road on the southern boundary of the site, through a controlled access gate.

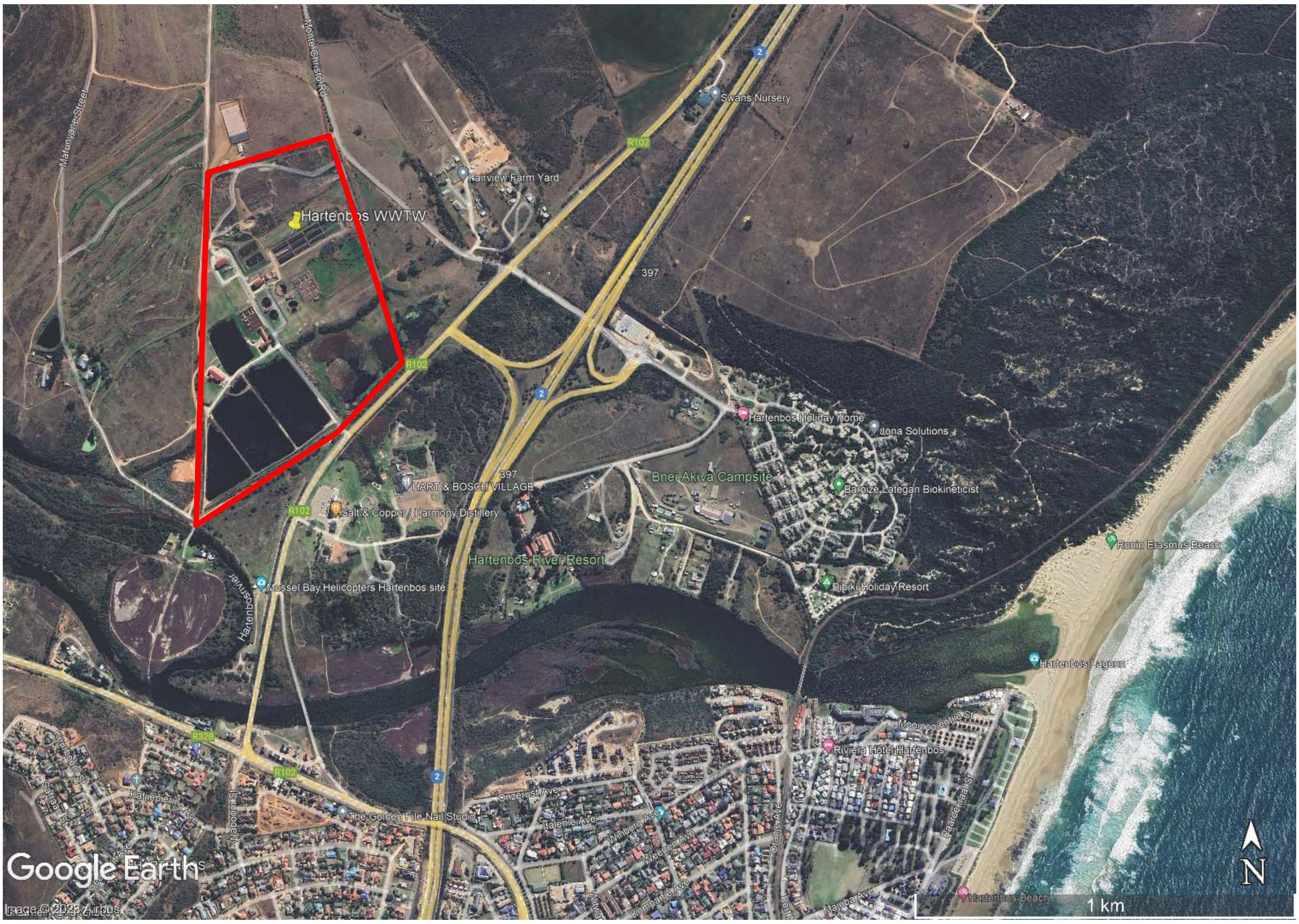


Figure 2-1: Project Location: Hartenbos WWTW

The site layout of the Hartenbos WWTW, as well as a proposed area for the installation of PV Solar Array is indicated in Figure 2-2 below.

The image also indicates the following:

1. Main Incoming 11kV Overhead Line from Main Intake Substation
2. Position of Main Incoming RMU
3. Position of MS A (Aerator supply)
4. Position of MS B (New Plant MCC)
5. Position of MS C (Old Plant MCC)
6. Position of MS RO Plant
7. Position of Control Room
8. Position of New Plant MCC Room
9. Position of Old Plant MCC Room

Figure 2-2: Site Layout: Hartenbos WWTW (Existing)

2.3 Site Conditions

The following table provides a summary of the site conditions:

Applicable Site Condition	**Value**
Ambient temperature (highest)	37°C (January)
Ambient temperature (lowest)	1°C (August)
Ambient temperature (average)	17°C
Altitude	110m
Average relative humidity	74%
Lightning flash density	Up to 1 flash/km^2/annum
Level of atmospheric pollution	Low
Corrosion conditions	Moderate
Average rainfall	400mm/annum
1:50 Year quantiles of annual maximum gusts	40-45 m/s
Distance from sea	2 km

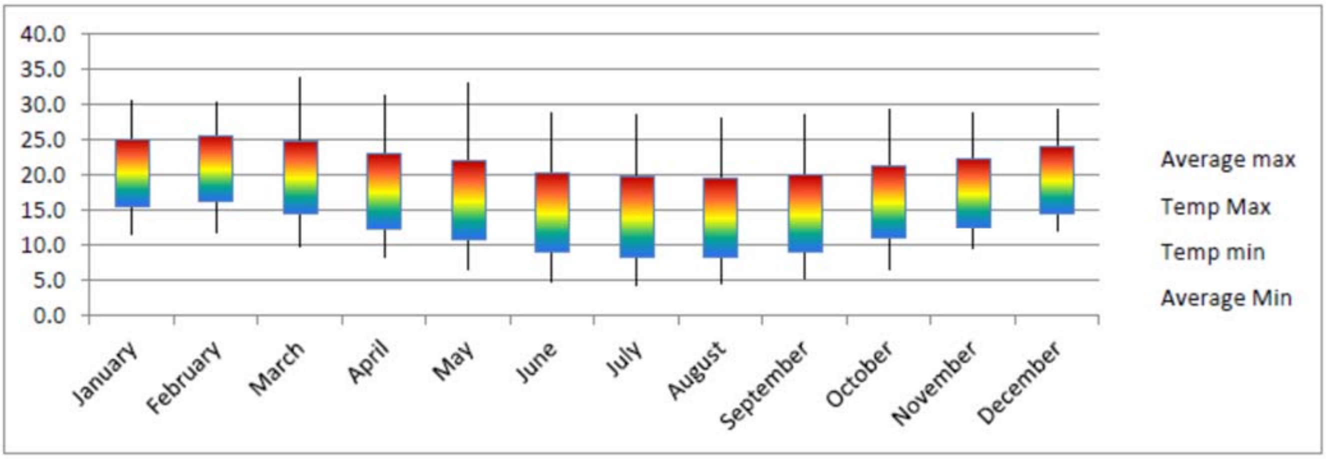


Figure 2-3: Ambient Temperature Variation for Mossel Bay Area

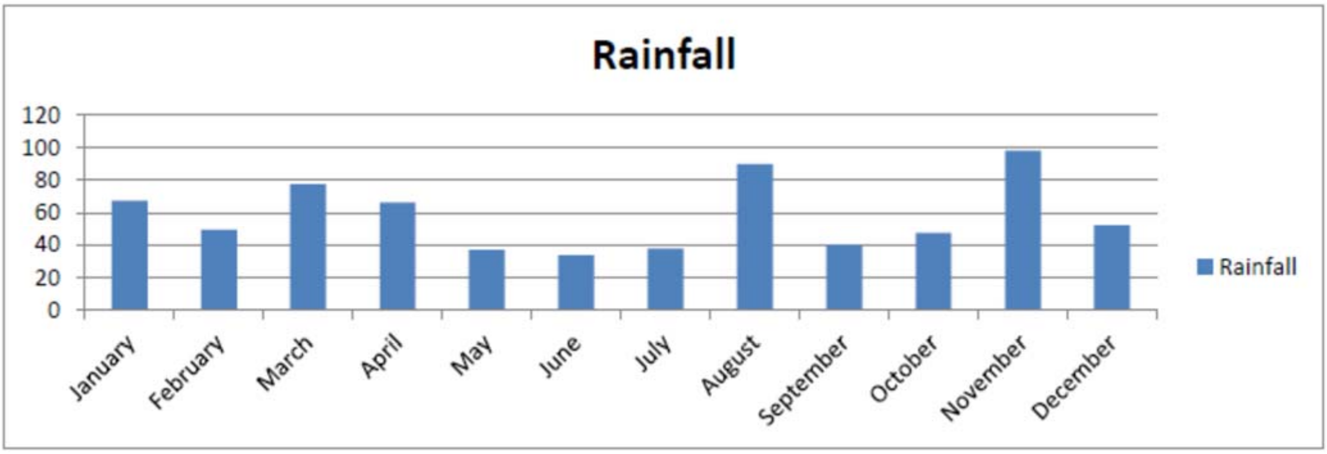


Figure 2-4: Average Rainfall for Mossel Bay Area

3 ELECTRICAL NETWORK ASSESSMENT

3.1 Network Configuration (Existing)

As can be seen from Figure 3-1, the Hartenbos WWTW Plant equipment is currently being supplied via four (4) 400 kVA, 11/0.4kV minisubs, feeding onto Main LV Boards (400V-MCCs), from which the distribution to the various pumps, aerators and other plant equipment is being done. The bulk medium voltage connection (normal supply) to the plant is via an 11kV overhead line from the Main Intake (66/11kV) Substation, which feeds onto an RMU, located in close proximity to MS-B and MS-C, as indicated in Figure 2-2.

An alternative (standby) bulk MV connection to the plant is via an 11kV overhead line from the Sonskynvallei (66/11kV) Substation, which feeds onto RMU-1, located near MS-RO Plant.

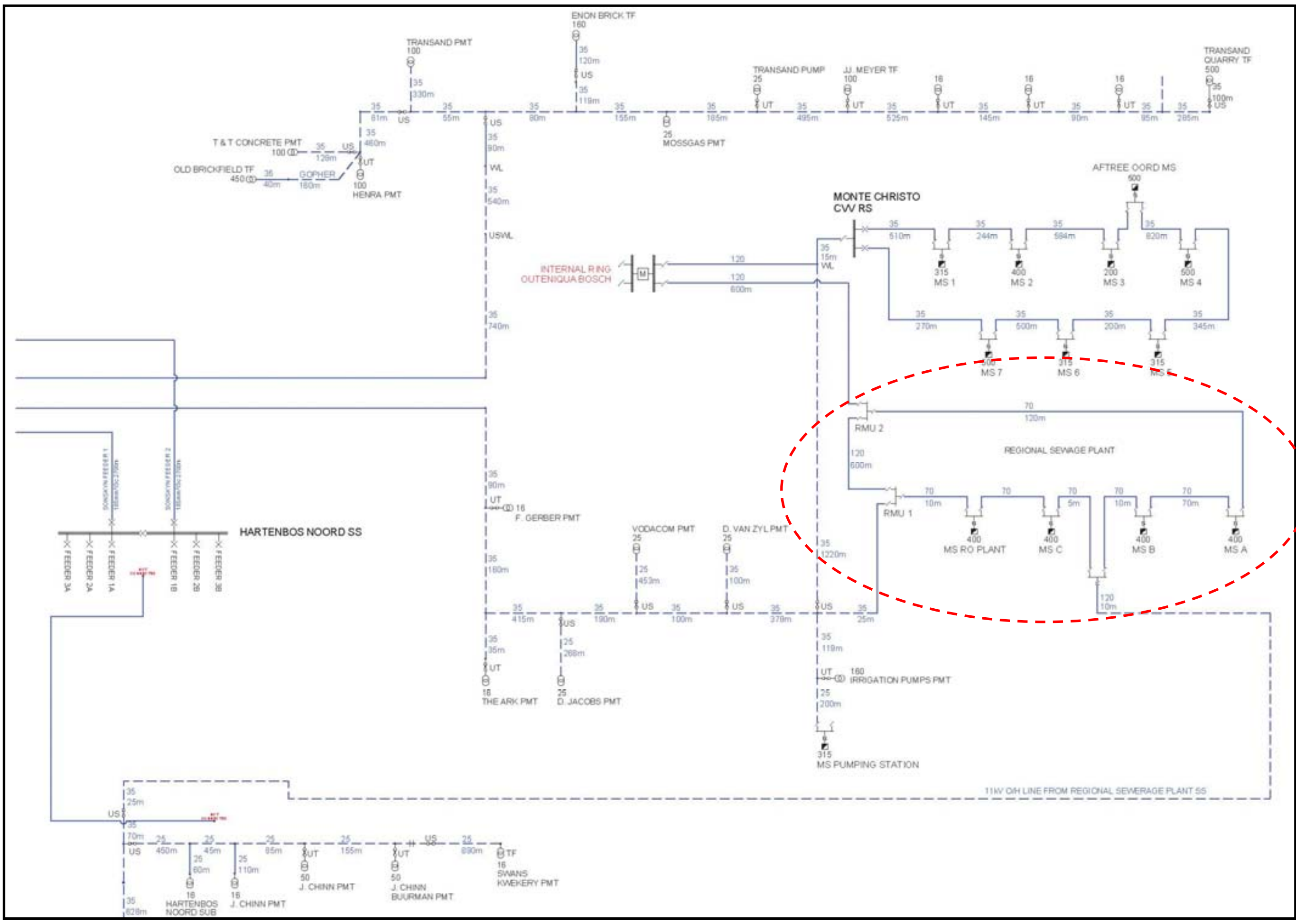


Figure 3-1: Network SLD: Hartenbos WWTW

Due to its criticality, the plant is also equipped with a 250 kVA (200 kW) diesel generator, providing a 4-6 hour standby capability with local on-site diesel storage capacity to some of the most critical equipment. It is important to note that this generator is not sized to provide backup to the full load capacity of the overall plant.

3.2 Load Profile Data

Each of the minisubs are being metered separately. The load profile recorded values for May 2023 are indicated in the graphs below.

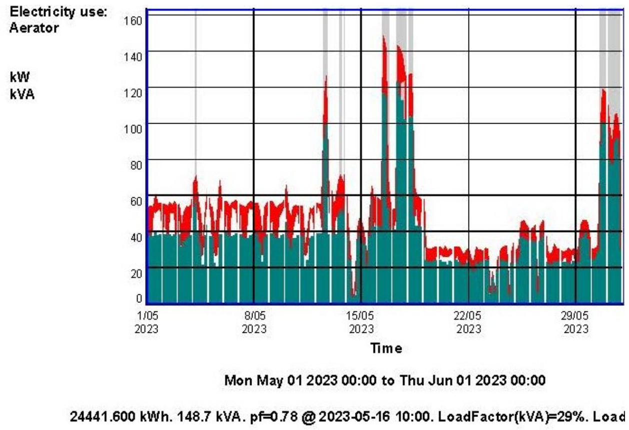


Figure 3-2: Aerator (MS-A)_May'23

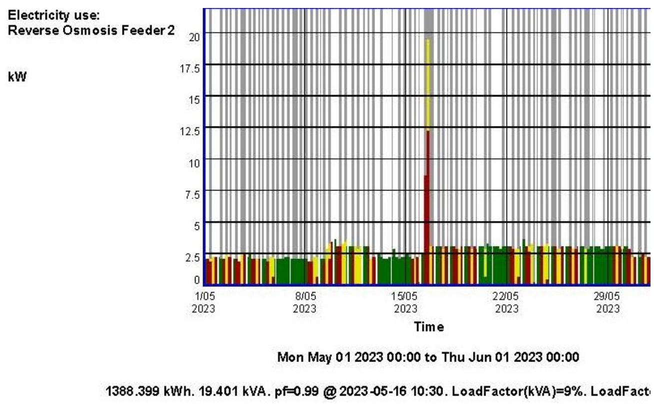


Figure 3-3: Reverse Osmosis Plant (MS-RO)_May'23

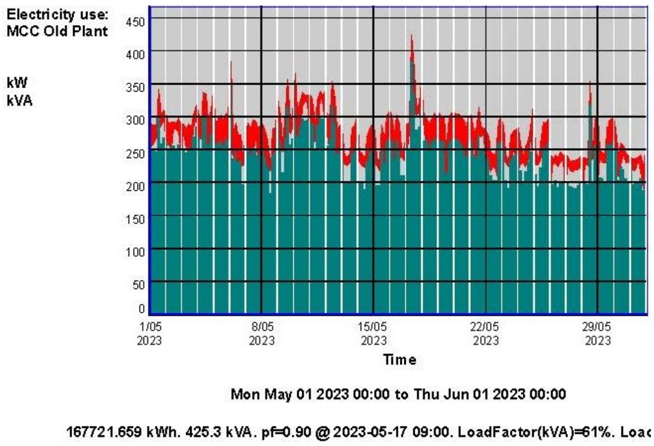


Figure 3-4: MCC Old Plant (MS-B)_May'23

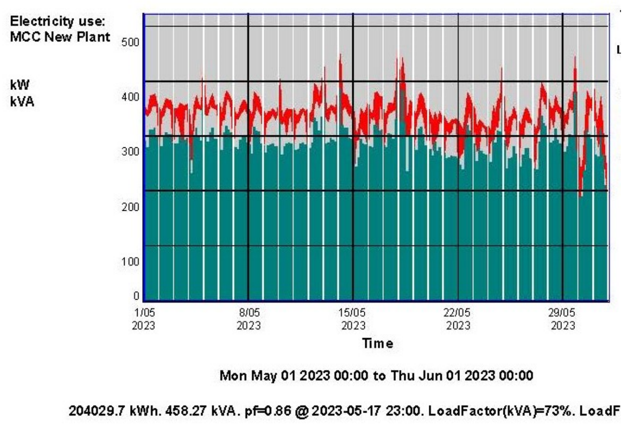


Figure 3-5: MCC New Plant (MS-C)_May'23

The individual metering data was obtained for each of the meters for the same metering period (01 January 2023 to 23 June 2023) and summated to determine the overall demand for the entire plant area. Table 3-1 below provides a summary of the recorded values for this time period.

Description	P (kWh)	Q (kVArh)	S (kVAh)	S (kVA)
Total recorded	3199853	2087173	3839201	
Average per month	554888	361937	665757	
Average per day	18496	12065	22192	
Average per hour	771	503	**925**	
Maximum Demand				**1152**

Table 3-1: Hartenbos WWTW (Total Plant) - Load Profile Data (1 Jan 2023 – 23 Jun 2023))

It is important to note that for the metering period considered, five (5) x 45kVA floating aerator motors were not in services, as they were being refurbished. For this reason, their possible contribution to the overall plant load was taken into consideration by adding them as a constant load for the full duration of the period. The "estimated" loads for these motors have been included in the values listed in Table 3-1.

Furthermore, it should be noted that the Reverse Osmosis Plant was not in operation and therefore not included in the overall load estimations. Based on the information provided by the Mossel Bay Municipality, this plant is only used in extreme drought conditions and should not be included as part of the calculations for the PV Solar & BESS system.

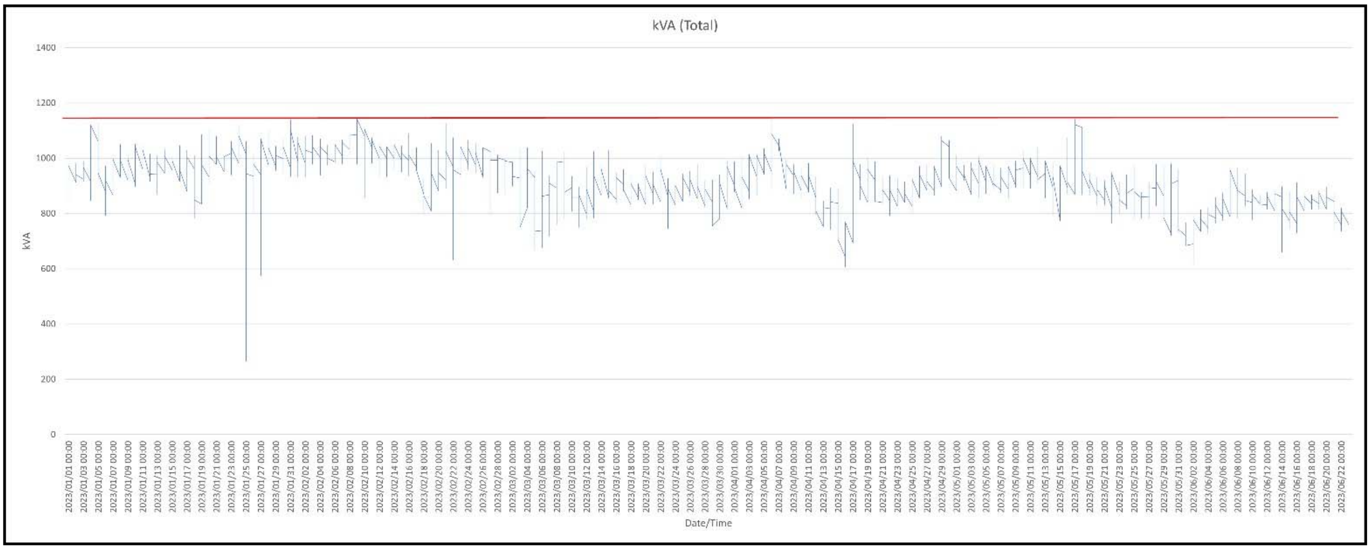


Figure 3-6: Maximum Demand (kVA) - Hartenbos WWTW

The maximum demand values for the recording period were also plotted, as indicated in Figure 3-6 above. As can be seen from these values, the highest value was recorded on 09 February 2023 (@22:00) as being 1152 kVA for the entire plant.

The most important information acquired from the load profile analysis, is the average energy consumption for the plant being 925 kWh and the maximum demand recorded for any specific half-hour period being 1152kVA. These values will be used in the calculations for the sizing of the PV solar plant, the inverters as well as the battery storage capacity.

4 PRELIMINARY DESIGN: ELECTRICAL

4.1 Specific Design Considerations

Specific design factors that were considered in the development of this solution included:

- Applicable tariff structures
- Scheduled network interruptions (load shedding)
- Seasonal consumption (load profile data)
- Project location
- Energy profiles (load profile data)
- Efficiency changes
- Array & mounting options
- Specific storage requirements

4.2 Proposed System Layout

The aim of the proposed solution was to design a hybrid system that will be grid-tied under normal operating conditions, providing battery backup as first line of support when the grid supply is interrupted. Furthermore, standby diesel generators will also be incorporated into the system design to serve as a final level of support to the load when the batteries are depleted and the grid supply (or PV solar generation) remains unavailable.

The proposed system configuration and how the various sub-systems are integrated is presented in Figure 4-1 below. It should be noted that each sub-system is described in more detail in later sections of this report.

In summary, it can be concluded that the proposed hybrid system will consist of the following:

a. 1760 kVA grid-tied, free-field solar PV installation (requiring ± 20 000m^2 installation area).
b. Installation of 3692 x 550Wp Mono-crystalline Solar Panels, which convert the solar radiation into direct current.
c. Fixed tilt ground mounting structures, which supports the PV modules.
d. 5x String inverters, which convert the DC from the solar field to AC.
e. 1x MV Inverter Station (3.2MVA), which collects the AC output from each of the inverters and incorporates a step-up power transformer, which steps the inverter output voltage up to the 11kV network voltage. The inverter station also has integrated 11kV switchgear to connect to the MV network.
f. 4512 kWh Battery Energy Storage System (consisting of 2x 2256kWh batteries in containers).
g. 1x 1.757 MVA Power Conversion System (PCS), which converts the DC battery output to AC power.
h. 1x 1.6 MVA Isolation transformer, which steps the PCS output up to 11kV.
i. 2x 800 kVA Backup Diesel Generators (containerised).
j. 1x 1.6 MVA Step-up transformer, which steps the generator output up to 11kV.
k. 6x 11kV (25kA) AIS switchgear panels, complete with associated protection, metering and control elements, to be housed in a new substation building.
l. 1x 11kV Neutral Earthing Resistor (NER), to be installed on the star-point of the generator step-up transformer's MV winding.
m. DC cables (LV).
n. AC cables (LV & MV).

o. Energy Management System.
p. Communication Network.

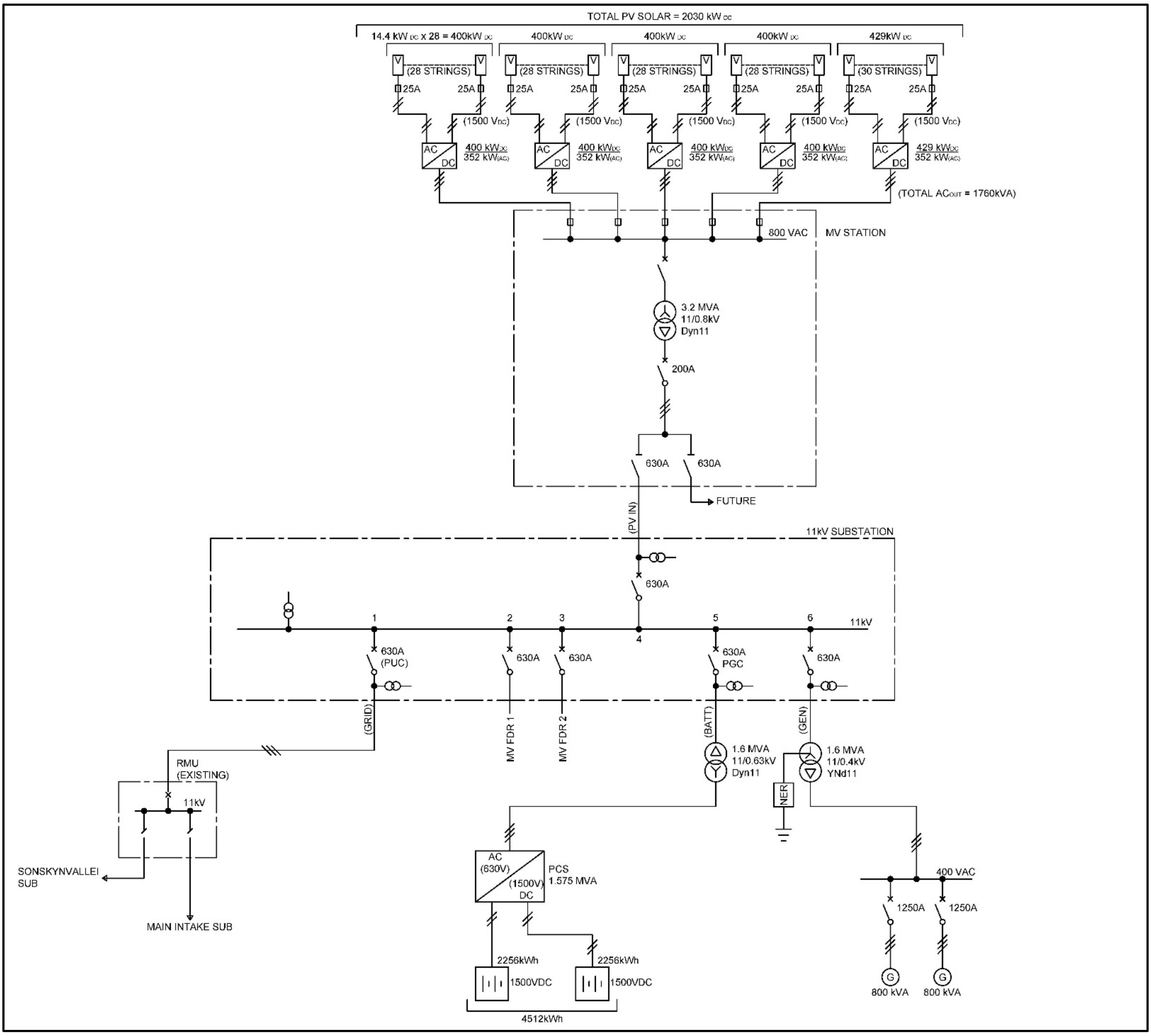


Figure 4-1: Proposed Hybrid System Layout

4.3 Proposed Network Re-configuration

The proposed re-configuration of the Hartenbos WWTW network, and the way in which the hybrid solution is integrated, is presented the figure below.

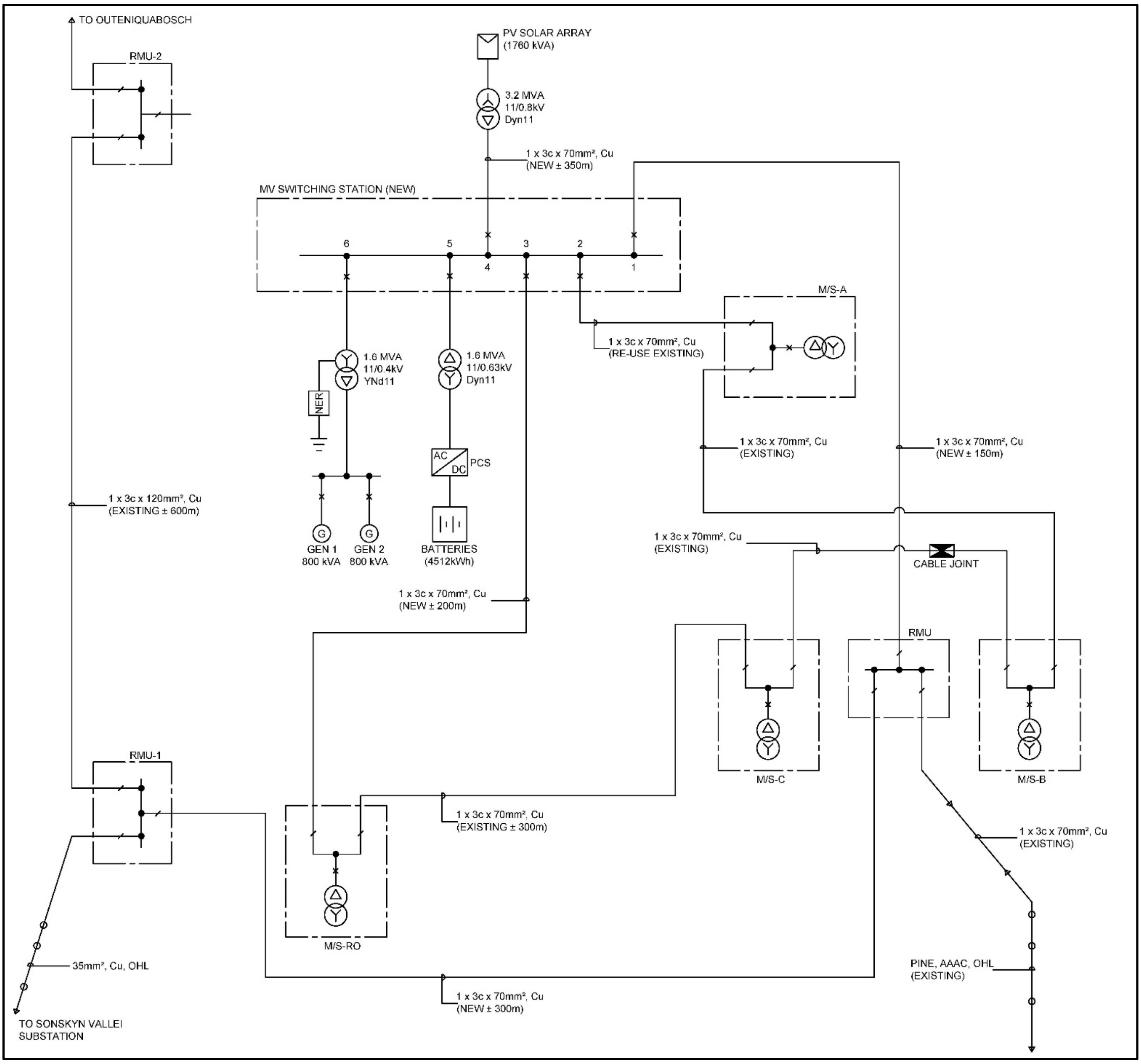


Figure 4-2: Proposed Network Configuration

In summary, it can be concluded that the proposed re-configuration of the 11kV network at the Hartenbos WWTW will consist of the following:

1. The existing 11kV (1x 3c x 70mm^2 Cu) cable from RMU-2 to M/S-A (approximately 120m in length) will be disconnected from RMU-2 and connected to the new 11kV Circuit Breaker 2 (MV Feeder 1) in the new MV Switching Station. This means that the alternative supply to the WWTW from RMU-2 will no longer be available as multiple utility connection points will not be permitted.
2. The existing 11kV (1x 3c x 70mm^2 Cu) cable from RMU-2 to RMU-1 (approximately 600m in length) will be left as is.

3. The existing 11kV (1x 3c x 70mm^2 Cu) cable from RMU-1 to M/S-RO (approximately 10m in length) will be disconnected from M/S-RO and extended with a new section of cable (approximately 300m in length) all the way to the Main Incoming RMU.
4. The Main Incoming RMU will be re-configured such that the Incoming Supply line from Main Intake Substation (via the AAAC, Pine OHL) will be connected to one of the network isolator switches, whilst the other Incoming Supply line from Sonskynvalley Substation (via the 35mm^2, Cu OHL connected to RMU-1) will be connected to the other network isolator switch. The circuit breaker of the Main Incoming RMU will be connected to the new 11kV Circuit Breaker 1 (PUC) in the new MV Switching Station via a new 11kV (1x 3c x 70mm^2 Cu) cable, approximately 150m in length. This re-configuration will result in the two alternative grid sources being available as a single utility source connection, depending on the supply selected.
5. The existing 11kV (1x 3c x 70mm^2 Cu) cable from M/S-C to M/S-RO (approximately 300m in length) will be left as is.
6. The existing 11kV (1x 3c x 70mm^2 Cu) cable from M/S-A to M/S-B (approximately 70m in length) will be left as is.
7. The existing 11kV (1x 3c x 70mm^2 Cu) cable from the Main Incoming RMU to M/S-B (approximately 10m in length) will be disconnected from the RMU and extended with a new section of cable (approximately 20m in length) to connect to M/S-C.
8. The existing 11kV (1x 3c x 70mm^2 Cu) cable from RMU-1 to M/S-RO (approximately 10m in length) will be disconnected from RMU-1. A new section of cable (approximately 200m in length) will be installed from M/S-RO to the new 11kV Circuit Breaker 3 (MV Feeder 2) in the new MV Switching Station to complete the 11kV ring network.

4.4 Proposed Site Development Plan

The proposed site development plan, indicating the positions for the new equipment associated with the hybrid energy solution, is indicated in Figure 4-3 below. These positions are purely indicative for preliminary design purposes and will need to be further investigated as part of the detail design development. (A full-scale drawing of the proposed SDP has been included as an annexure to the report).

The main reason for the chosen positions is its central location between all of the different network components that need to be integrated. This ensures optimal cable lengths as well as easy access to all equipment for operation and maintenance purposes.

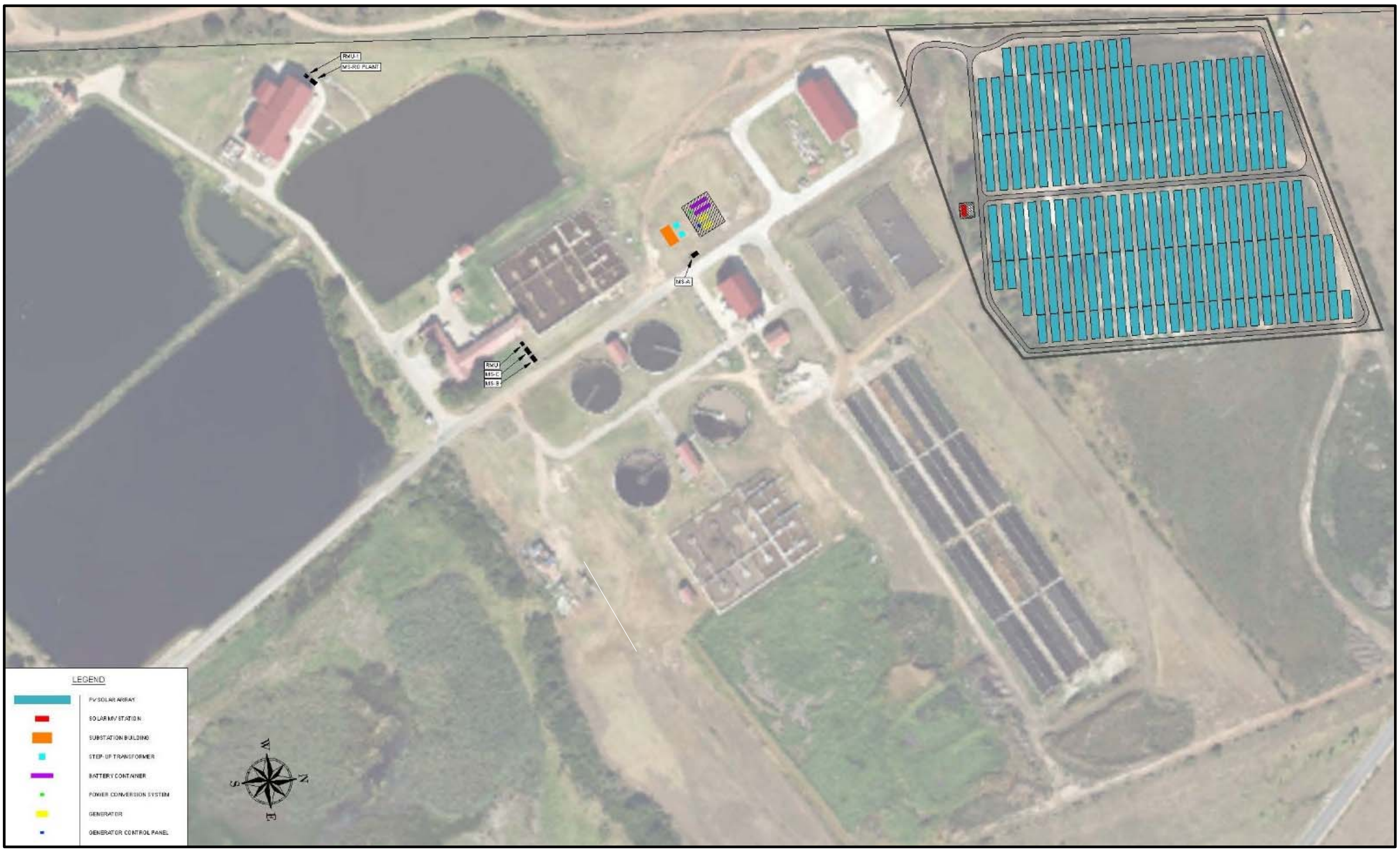


Figure 4-3: Proposed Site Development Plan

4.5 Proposed System Operation

4.5.1 Normal Operations (Grid Supply Available)

The aim of the proposed solution was to design a hybrid system that will be grid-tied under normal operating conditions, meaning that (with reference to Figure 4-1 above):

1. Grid supply is available and connected. 11kV Circuit Breaker 1 (PUC Breaker) will be closed.
2. Load breakers (Circuit Breakers 2 & 3) are closed and 11kV ring network is supplying load.
3. PV Solar array is connected (Circuit Breaker 4 is closed) and all available solar energy is:
    a. Supplying load (via Circuit Breakers 2 & 3);
    b. Charging batteries (via Circuit Breaker 5);
    c. Exported into grid (surplus, via Circuit Breaker 1);
4. Batteries are maintained at a 100% state-of-charge (SOC) for backup purposes (Circuit Breaker 5 is closed). Power Conversion System (PCS) is operated in “Grid Following Mode”.
5. Generators are switched off and disconnected from the network (Circuit Breaker 6 is open).
6. 11kV Neutral Earthing Resistor (NER) on the star-point of the generator step-up transformer is therefore not connected to the network, due to Circuit Breaker 6 being open.

Under these normal operating conditions, with Eskom (grid) supply being available, the system will be operated in “peak-shaving” mode for the different periods of the day, as summarised in the table below.

Time of Day	Tariff	Load	Batteries	PV Solar	Diesel Gen
00:00-06:00	Off-peak	From Grid	Charged from Grid	None	Standby only
06:00-08:00	Peak	From Batteries	Discharged	Limited	Standby only
08:00-10:00	Peak	From Grid	Charged from PV	Charge Batteries	Standby only
10:00-18:00	Standard	From Grid/PV	Charged from PV	Charge Batteries & Load	Standby only
18:00-20:00	Peak	From Batteries	Discharged	None	Standby only
20:00-24:00	Off-peak	From Grid	Charged from Grid	None	Standby only

Table 4-1: Normal Network Conditions - Battery Storage Capacity Used for Peak-shaving

Under these normal operating conditions, with Eskom (grid) supply being available, the system could be operated in "peak-shaving" mode for the different periods of the day, as summarised in the table below.

If, as an example, we assume that stage 4 load shedding is being applied, which would require two interruptions (two hours in the morning and two hours in the evening), the application of the battery storage capacity could typically be as follows:

Time of Day	Tariff	Load	Batteries	PV Solar	Diesel Gen
00:00-04:00	Off-peak	From Grid	Charged from Grid	None	Standby only
04:00-06:00	Off-peak - Loadshedding	From Batteries	Discharged	None	Standby only
06:00-08:00	Peak	From Grid	Charged from Grid to 50%	Limited	Standby only
08:00-10:00	Peak	From Eskom	Charged from Grid / PV Solar to 100%	Charge Batteries & Supply Load	Standby only
12:00-14:00	Standard – Loadshedding	From Batteries / PV Solar	Charged from PV	Charge Batteries & Supply Load	Standby only
14:00-18:00	Standard	From Grid / PV Solar	Charged from PV	Charge Batteries & Supply Load	Standby only
18:00-20:00	Peak	From Batteries	Discharged	None	Standby only
20:00-24:00	Off-peak	From Grid	Charged from Grid	None	Standby only

Table 4-2: Load-shedding Conditions - Battery Storage Capacity Used for Back-up Supply

If the Mossel Bay Municipality, however, is notified that load-shedding will be implemented within the following 24 hours, the battery storage capacity should rather be used to supply the load during the outage, instead of the more expensive diesel generator set.

4.5.2 Island Operations (Grid Supply Interrupted)

With reference to Figure ***4-1*** above under abnormal conditions, with the normal grid supply being interrupted for reasons such as fault conditions or load shedding, the hybrid system will enter "island mode" and will respond as follows:

1. Grid supply is interrupted, and the supply voltage sensed by the cable VTs on the incoming line falls to zero volts. 11kV Circuit Breaker 1 (PUC Breaker) opens within 100ms to island the system.
2. Circuit Breaker 6 (generator transformer breaker) is closed within milliseconds, to ensure that the 11kV Neutral Earthing Resistor (NER) on the star-point of the generator step-up transformer is immediately connected to the network, to ensure MV system earthing.
3. The generators remain off and the 400V generator circuit breakers remain open.

4. The String Inverters of the PV Solar array senses a "loss of voltage" and immediately shuts down, disconnecting any form of solar generation (NRS 097 compliance). Circuit Breaker 4 remains closed, as the disconnection of the PV supply occurs at inverter level.
5. The PCS, controlling the batteries also senses a "loss of supply" and immediately disconnects the system and switches to "Grid Forming Mode" to start supplying the load via the batteries (Circuit Breaker 5 remains closed). This change-over occurs within milliseconds, which means that non-sensitive equipment, such as plant lighting and some motors (without VSDs or sensitive undervoltage protection) will remain in operation. Control systems (supplied via separate UPSs) should also remain operational. Sensitive equipment, such as soft starters and VSDs will disconnect to protect their electronic systems. This means that sections of the plant will be interrupted.
6. Load breakers (Circuit Breakers 2 & 3) remain closed and 11kV ring network supplies the load with the stored energy from the batteries.
7. Motor loads that were interrupted during the change-over will be started manually via the Plant SCADA or in the field.
8. The String Inverters of the PV Solar array senses that the system voltage is restored (from the BESS) and PV Solar array is re-connected, and all available solar energy is:
    a. Supplying load (via Circuit Breakers 2 & 3);
    b. Exported into grid (surplus, via Circuit Breaker 1);
9. The available PV solar energy and battery storage capacity will be used to supply the load until the Grid Supply is restored.
10. Should the available PV solar energy be insufficient to supply the load and the battery storage capacity is drained to a pre-configured value (maybe 20% SOC), the Energy Management System will be configured to automatically start both the standby diesel generators.
11. Once the generators are up to full speed, they will be synchronized to the network across the 400V generator circuit breakers and will start to supply the load. Based on the load demand at that stage, the Energy Management System will determine if both generators are required to supply the load or if one could be switched off (fuel save mode).

4.5.3 Return to Normal Operations (Grid Supply Restored)

With reference to Figure 4-1 above, with the system operated in "island mode" as described in Section 4.5.2, and the normal grid supply being restored, the hybrid system will respond as follows:

1. Grid supply is restored, and the supply voltage sensed by the cable VTs on the incoming line remains at 11kV for a minimum pre-determined period (typically 60 seconds) to confirm that the grid supply is stable.
2. The PCS, controlling the batteries also senses a "return of grid supply" and disconnects the system within 60 seconds and switches back to "Grid Following Mode" (Circuit Breaker 5 remains closed). Supply to all plant loads will be interrupted for the duration of returning the system to normal.
3. The Energy Management System will determine if any of the generators are in operation and will switch them off. 400V Generator circuit breakers are opened. 11kV Circuit Breaker 6 remains closed to ensure that the 11kV Neutral Earthing Resistor (NER) on the star-point of the generator step-up transformer remains connected to the network, to ensure MV system earthing.
4. The String Inverters of the PV Solar array senses a "loss of voltage" and immediately shuts down, disconnecting any form of solar generation (NRS 097 compliance). Circuit Breaker 4 remains closed, as the disconnection of the PV supply occurs at inverter level.
5. Load breakers (Circuit Breakers 2 & 3) remain closed. At this stage all forms of supply to plant loads are switched off.

6. 11kV Circuit Breaker 1 (PUC Breaker) is closed, under dead-bus conditions, although still being sync-checked before closing the breaker.
7. Circuit Breaker 6 is opened immediately after Breaker 1 is closed, disconnecting the 11kV Neutral Earthing Resistor (NER) on the star-point of the generator step-up transformer from the 11kV network.
8. PCS restarts in "Grid Following Mode" and immediately starts recharging the batteries from the grid or available PV back up to a 100% state-of-charge (SOC). Circuit Breaker 5 remains closed.
9. The String Inverters of the PV Solar array senses that the system voltage is restored (from the BESS) and PV Solar array is re-connected, and all available solar energy is:
    a. Supplying load (via Circuit Breakers 2 & 3);
    b. Charging batteries (via Circuit Breaker 5);
    c. Exported into grid (surplus, via Circuit Breaker 1);
10. All plant loads that were interrupted during the change-over will be started manually via the Plant SCADA or in the field and the system is returned to normal.

4.6 Software Simulations

In order to accurately determine the optimal sizing of the various sub-systems that would make up a micro-grid, such as would be required when the normal supply to the Hartenbos WWTW is interrupted and the plant is islanded, the HOMER ® Software package was used. HOMER is a simulation model that attempts to simulate a viable system for all possible combinations of the equipment that one wishes to consider. Depending on how the problem is configured, HOMER simulates hundreds or even thousands of systems in order to determine the most optimal solution. HOMER simulates the operation of a hybrid microgrid for an entire year, in time steps from one minute to one hour, based on actual load profile data provided.

The following paragraphs provide extracts from the studies, which were performed to show how the results were derived. The PV Yield simulation software used takes into consideration the average ambient temperatures and rainfall for the Mossel Bay area as these have a major impact on the potential PV solar generation.

An average annual irradiation of 1420 kWh/kWp/year, resulting in a performance ratio of 75.51% (which is typical for the Southern Cape Region) was used for the purposes of calculation.

4.7 Proposed PV Solar Plant

The simulation software calculated that the rated power of the PV Plant required to supply the load requirements, will be 1760.0 kWac and the peak power is 2030.6 kWdc resulting in a DC/AC ratio of 1.15.

MOSSEL BAY IPP TENDER Project	
Main characteristics	
Location	South Africa, Western Cape
Rated power (AC)	1760.0 kWac
Peak power (DC)	2030.6 kWdc
Ratio DC/AC	1.15
General Equipment	
Fixed structure	80
PV Modules (550.0 Wp)	3692
Power station (up to 1760.0 kW)	1
Number of inverters (up to 352.0 kVA)	5

Table 4-3: PV Solar Plant Sizing

4.7.1 Proposed PV Array Layout

The figure below provides a typical arrangement of the PV Solar panels and associated mounting frames, taking into account the slope and orientation of the land available. As can be seen from this image, a total area of approximately 20 000m^2 (2 ha) will be required for the installation of the 3692 x 550Wp Solar Panels on Fixed Tilt Ground Mounted System.

Area Name	Area	Suitable Area	Fence Area
Area 1	5.41 ha	2.35 ha	1.99 ha
Total	**8.76 ha**	**2.35 ha**	**1.99 ha**

Table 4-4: PV Solar Plant Sizing

Figure 4-4: Proposed PV Array Arrangement

4.7.2 Topography

A preliminary terrain topography analysis was performed to study the suitability of the terrain for the construction of a photovoltaic plant. The North-South and East-West slopes were calculated and are shown in Figure 4-5 below.

The grid resolution of the elevation data is 30.0 m (North-South and East-West directions). This data was provided by Google Earth (SRTM-30).

The analysis of the terrain slopes resulted in three differentiated areas:

- Zones where the slope is lower than 5.00 %.
- Zones where the slope is between 5.00 % and 10.00 %.
- Zones where the slope is greater than 15.00 %.

NOTE: The slopes measured on site when performing a detailed topographical analysis could be greater than the slopes obtained using this analysis.

The map shown in the Figure 4-5 represents the slopes of the terrain, with the following colours representing:

- Slopes <5.00 %
- Slopes >5.00 % and <10.00 %
- Slopes >10.00 % and <15.00 %
- Slopes >15.00 %

Using the previously mentioned elevation data, the position of the mounting structures in the terrain was calculated. The slope of the terrain in the North-South and East-West directions under the structures was calculated. The position of the structure posts was also calculated, including ground elevation and post height.

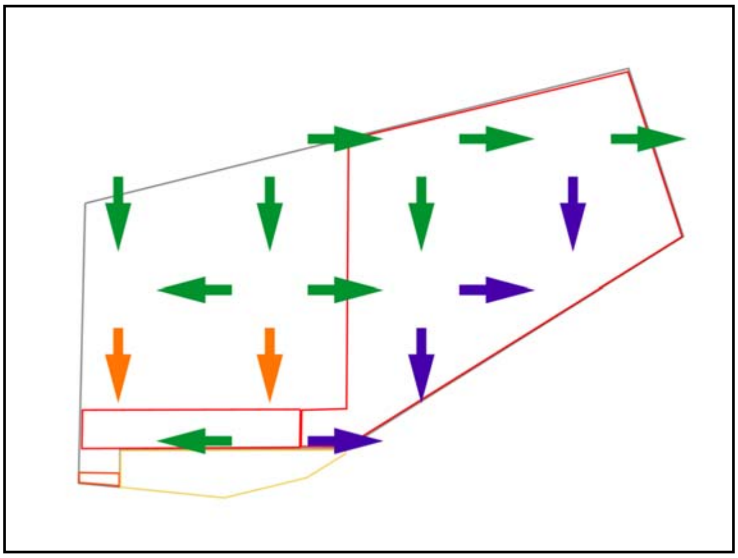


Figure 4-5: Slopes of the Plot Area

4.7.3 Horizon Profile

The solar irradiance reaching the photovoltaic modules will change if there are hills or mountains on the horizon. These physical obstructions will block the beam component of the irradiance during some periods of the day and will have an impact on the diffuse component as well. Therefore, the horizon profile directly impacts the energy yield of the photovoltaic plant.

The horizon line has an average elevation of 2.4° and a maximum elevation of 5.3°. Throughout the year, the sun will be blocked by the horizon line for a total of 216 hours. The data source for the horizon line was PVGIS 5.2.

The blocked elevations over the complete azimuth range are shown in Figure 4-6.

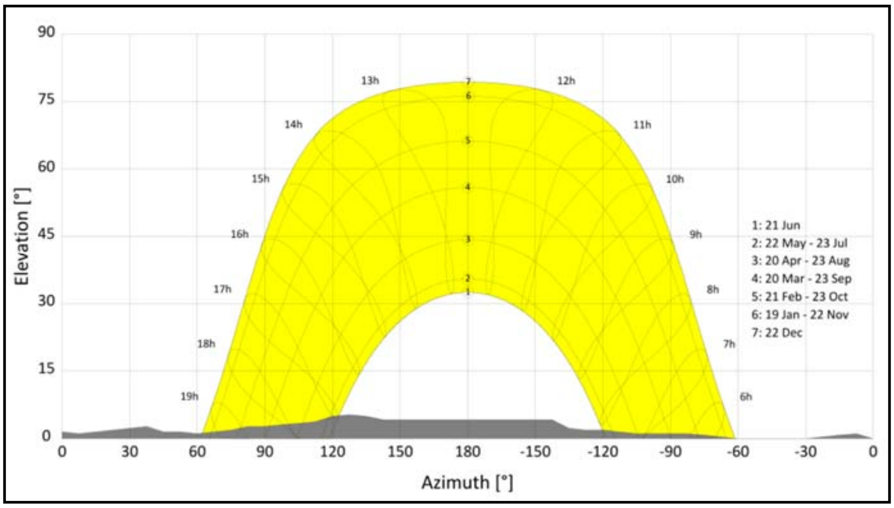


Figure 4-6: Horizon profile (data source: PVGIS 5.2)

4.7.4 Solar Resource Analysis

The aim of the solar resource analysis is to provide an estimation of the solar energy the photovoltaic plant would receive throughout a typical year.

The solar resource is usually given as a series of hourly values for the irradiance and temperature, for a period of one year. This series is called the Typical Meteorological Year (TMY).

The source used to generate the TMY was the PVGIS database. It includes meteorological data ranging from 2005 to the present (the actual period used may vary depending on the location) and has a spatial resolution of 4 km by 4km. The uncertainty of the PVGIS data varies between ±3% to ±10%, depending on the location.

The hourly temperature values found in the TMY yield the following aggregates:

- Minimum temperature: 4.3 °C.
- Maximum temperature: 36.05 °C.
- Average temperature: 16.97 °C.

The results of the solar resource analysis are shown in Table 4-5. A chart representing these results is shown in Figure 4-7.

Month	GHI [kWh/m2]	DHI [kWh/m2]	Temperature
1	209.2	64.6	20.22 °C
2	171.1	58.2	20.64 °C
3	159.2	47.2	20.13 °C
4	118.3	41.2	17.31 °C
5	94.0	34.2	16.33 °C
6	65.8	29.4	14.35 °C
7	83.2	29.3	13.5 °C
8	110.8	39.8	13.33 °C
9	140.0	49.5	14.34 °C
10	182.8	63.4	15.71 °C
11	190.8	67.1	17.24 °C
12	246.1	67.0	20.72 °C
Year	**1771.4**	**590.9**	**16.99 °C**

Table 4-5: Solar Resource (Monthly)

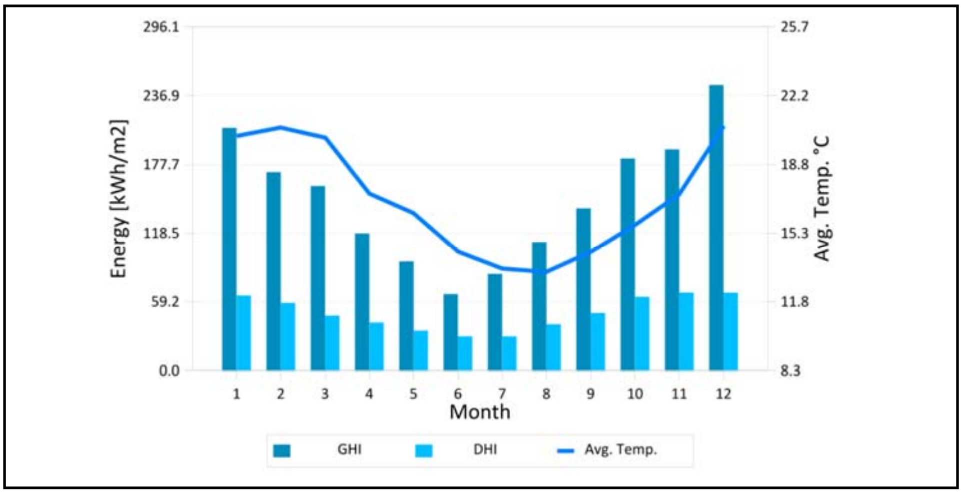


Figure 4-7: Monthly PV Solar Yield (Average)

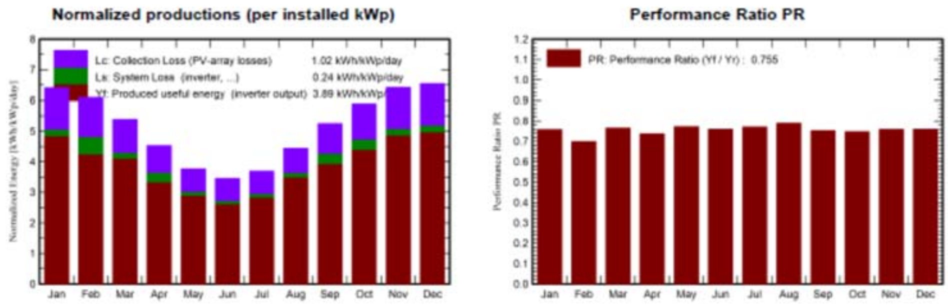
Direct irradiance (DHI) is the part of the solar irradiance that directly reaches a surface; diffuse irradiance is the part that is scattered by the atmosphere; global irradiance (GHI) is the sum of both diffuse and direct components reaching the same surface.

System Production

Produced Energy 2883.37 MWh/year

Specific production 1420 kWh/kWp/year

Perf. Ratio PR 75.51 %



Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	200.1	71.00	21.40	198.6	177.5	319.4	305.7	0.758
February	163.2	54.90	21.60	170.5	152.9	275.0	242.0	0.699
March	150.5	52.70	20.40	166.9	149.8	271.2	259.5	0.765
April	114.3	40.80	18.20	136.0	121.2	223.1	203.9	0.738
May	91.2	34.10	16.40	117.0	102.2	191.1	183.4	0.772
June	77.0	27.60	14.60	103.6	88.3	166.6	160.2	0.761
July	87.0	30.70	13.80	114.5	99.0	186.8	179.3	0.771
August	111.4	40.00	14.20	137.6	122.3	230.3	220.6	0.789
September	138.8	51.90	15.30	157.5	140.9	261.1	240.7	0.753
October	172.5	64.20	17.10	182.8	163.9	299.3	277.5	0.748
November	191.3	66.90	18.50	192.5	172.5	310.7	297.0	0.760
December	206.4	73.80	20.29	202.9	181.6	327.6	313.5	0.761
Year	1703.7	608.60	17.63	1880.4	1672.2	3062.0	2883.4	0.755

Figure 4-8: Annual PV Solar Yield (PV Syst V7.4.0)

4.8 Proposed Battery Energy Storage System

Based on the load profile data and solar yield calculations for this specific system, it was calculated that a 4512 kWh Battery Storage System (2x 2256kWh units) will be the optimal size for this application.

The results from the HOMER software simulations, used to model a Stage 6 load shedding schedule (4 hour + 2 hour outage per day), indicated that this battery will support this specific plant load all year round, which should be sufficient to ensure an almost off-grid operation of the entire plant.

Should a number of consecutive overcast/rainy days be experienced that would result in the batteries not being sufficiently charged, a standby generator will be incorporated to support the load until the grid supply is restored.

4.9 Proposed Standby Generators

It is recommended that the backup generators required for this hybrid solution needs to consist of 2x 800 kVA (637kWe prime power) units, which will be used for directly supporting the full load of the plant.

The generator/s starting will be controlled (intelligently) by the Energy Management System and will only be started when the battery capacity reaches a pre-determined value such as 20% state-of-charge (SOC). The generators will then be started and synchronised to the system to support the full load capacity of the plant, whilst waiting for the grid supply to return or the PV solar system to re-charge the batteries back to a certain value. This philosophy will result in a huge cost saving on diesel, as the generators will no longer be the primary source of backup supply and will only be used to support the load when the battery storage capacity is depleted. According to the Homer software simulations, it is estimated that for a typical stage 6 load shedding schedule (with 4-hours and 2-hours interruptions of grid supply), this should only occur approximately 3-4 times per annum with the proposed hybrid system configuration.

When required, both generators will be started simultaneously by the Energy Management System, and one will be switched off (depending on the load requirements) to operate in "fuel save mode" and avoiding a situation where both generators are running at less than 50% of capacity.

4.10 Specific Equipment Requirements

4.10.1 Mounting Structures

The PV solar modules will be mounted on a fixed structure. The structure will establish the orientation and inclination of the modules, as well as the separation between the rows. The structure/s will be composed of at least the following elements:

- A mounting structure formed by different types of metallic profiles.
- Foundation elements for anchoring the structure to the ground.
- Clamping elements and screws to assemble the structure and for mounting the modules on the structure.
- Structural reinforcement elements.

The preferred mounting structure will be of a landscape orientation with a fixed tilted angle of 29° (or calculated as per exact location). The structure should be capable of supporting the solar modules securely for the intended generation life of the installation. The mounting structure shall be installed to follow the contours of the site and shall be assembled with standard tools.

All structures shall have a minimum ground clearance of 600mm ± 25mm at the lowest point. A typical arrangement is shown in Figure 4-9 below. It should, however, be noted that the final tilt angles and distances between arrays will be determined from the detail designs for each specific site, based on the slope and orientation.

Foundations (if applicable) shall not impact the environment of the Site and must be dismountable at the end of the solar plant operation life.

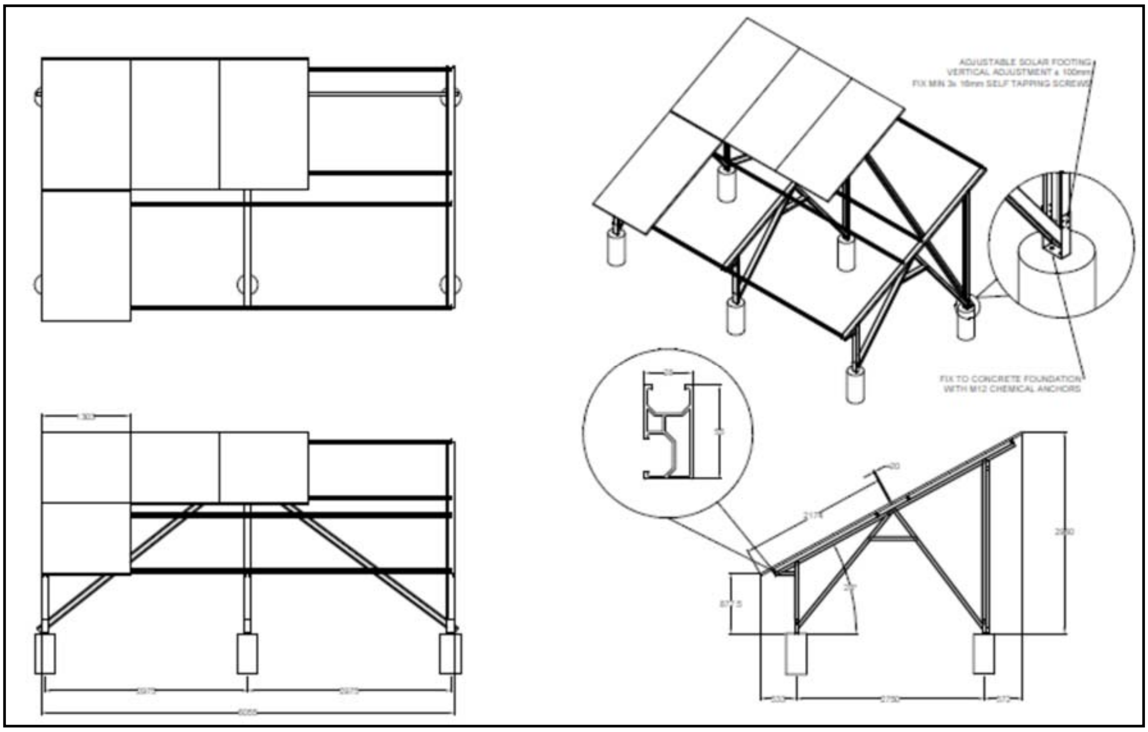


Figure 4-9: Typical PV Mounting Structure Configuration

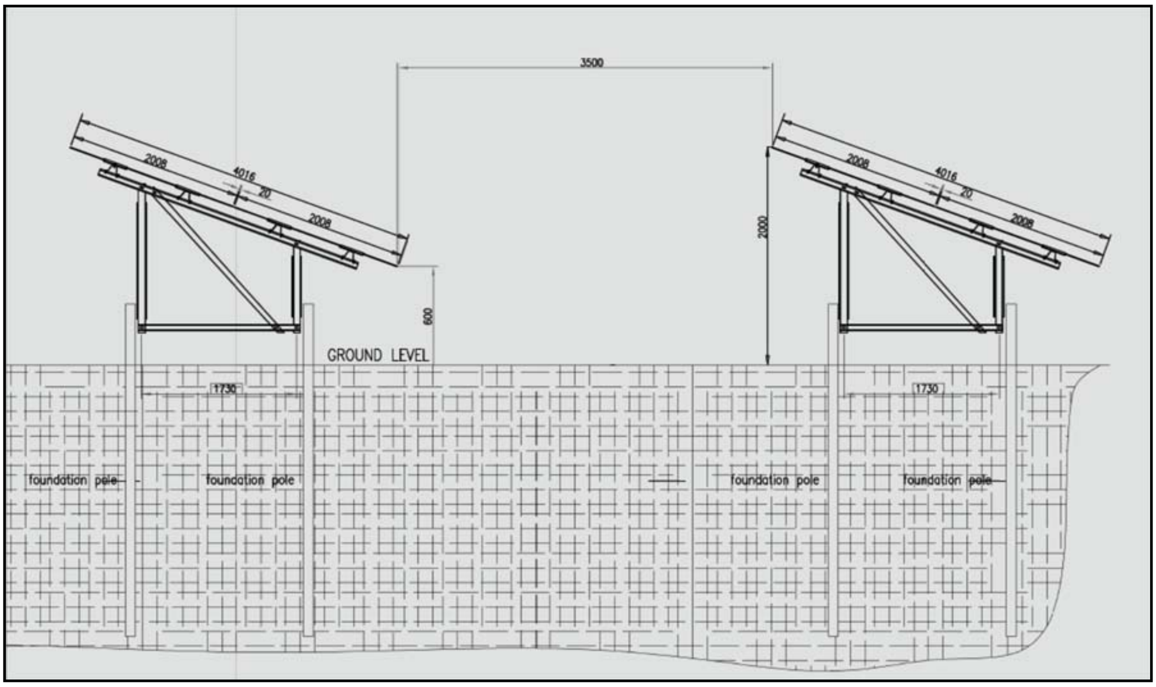


Figure 4-10: Typical PV Array Spacing

4.10.2 Photovoltaic (PV) Modules

The Contractor shall supply and install the PV Modules to achieve the specified levels of performance for the required design life of 25 years under the prevailing site environmental conditions. PV Modules will have minimum product warranties of 12 years and minimum linear power output warranties of 90% of the nameplate power after 10 years and -0.4% per year thereafter up to 25 years.

The PV Modules offered shall:

- Be of the Mono-crystalline solar cell type only as per the latest edition of IEC 61215 Ed.2.
- Be of the same type, model and from a single manufacturer.
- Be chosen with the intention of maximizing the energy output per kW at low irradiation levels. Temperature performance will be considered in the selection.
- Be able to withstand hail (maximum diameter of 25 mm with impact speed of 23 m/s) according to regulations for PV panels set out in IEC 61215.

Figure 4-11: Typical Fixed-tilt Ground-mount System (2V Arrangement)

4.10.3 Inverters

The inverter converts the direct current produced by the photovoltaic modules to alternating current. It is composed of the following elements:

- One or several DC-to-AC power conversion stages, each equipped with a maximum power point tracking system (MPPT). The MPPT will vary the voltage of the DC array to maximize the production depending on the operating conditions.
- Protection components against high working temperatures, over or under voltage, over or under-frequencies, minimum operating current, mains failure of transformer, anti-islanding protection, protection against voltage gaps, etc. In addition to the protections for the safety of the staff personnel.

Inverters used shall be string inverters and have an NRS 097-2-1 compliance certification from an independent test institute, as well as comply with Standard Specifications. All inverters will be of the same manufacturer and type to ensure interconnectivity and ease of maintenance. Inverters will comply with South Africa Grid Code requirements.

Inverters will have a minimum protection class of minimum IP66.

All inverters will have a DC input voltage up to and including 1500 VDC and have an AC output voltage of 680-880 VAC.

Figure 4-12: Typical String Inverter

4.10.4 Inverter Canopy

Although all the string inverters will be at least IP66 rated, it is recommended that they be installed under a canopy to protect them against direct rain and sunlight. A typical canopy design that will be considered is indicated in the images below.

Figure 4-13: Typical String Inverter Canopy (Credit: Eversolar)

Figure 4-14: Inside of String Inverter Canopy (Credit: Eversolar)

4.10.5 MV Inverter Power Station

The inverter power stations, or transformer stations are housed in indoor buildings or containerised units. The voltage of the energy collected from the solar field is increased to a higher level to facilitate the evacuation of the generated energy efficiently. The inverters and power transformers will be housed in the inverter station.

The power station shall be supplied with medium voltage switchgear that include one transformer protection unit, one direct incoming feeder unit, one direct outgoing feeder unit and electrical boards.

Figure 4-15: Typical Inverter Power Station

4.10.6 Battery Energy Storage System

The battery energy storage system shall comprise of stationary batteries in series and parallel strings with sufficient number of cells to provide the rating specified. The battery bank rated output shall be that available at the outgoing terminals, after making due allowance for the resistance of intercell connections.

The major equipment items shall include a battery, power conversion system (PCS), output/isolation transformer, and local and remote control and monitoring equipment. Additional equipment shall include HVAC, wiring, connectors, protective devices, grounding, junction boxes and enclosures, instrumentation, enclosures, and all other items needed for a fully functional, utility-interactive system to meet the requirements.

Only Lithium-ion Phosphate (LiFePO4) or Lithium Ferro Phosphate (LFP) batteries with life expectancy rating of at least 10 years under normal operating conditions, suitable for outdoor installation, shall be considered.

The batteries shall be of the totally enclosed type and capable of providing the guaranteed output throughout the range of ambient conditions specified. The batteries shall be housed in a separate enclosure or containerised unit complete with the required control and monitoring equipment.

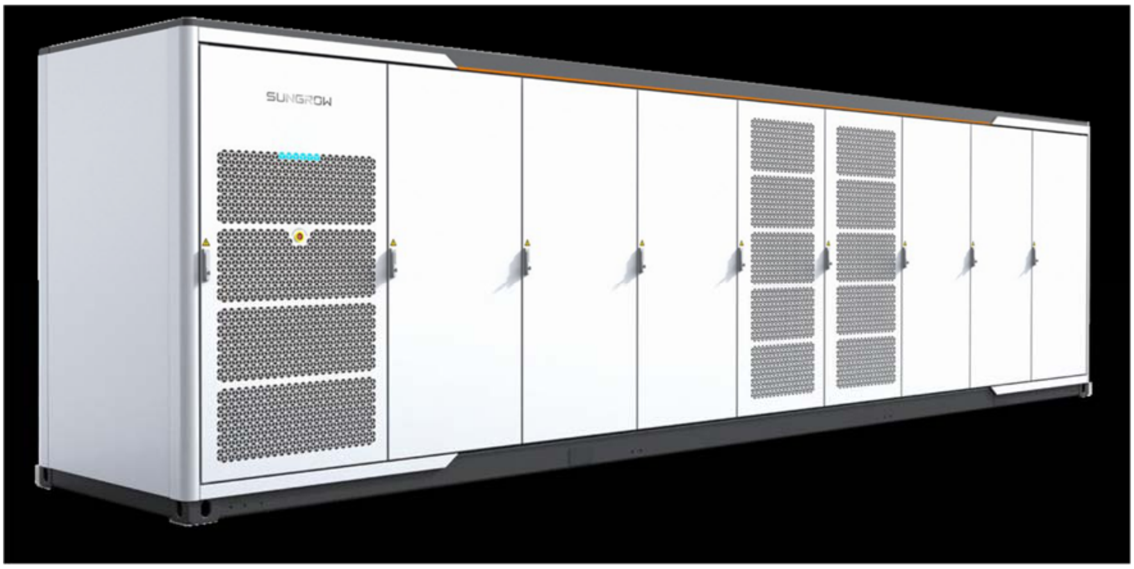


Figure 4-16: Typical 2.7 MWh Battery Storage Unit (Liquid Cooled)

4.10.7 Medium Voltage Switchgear

It is recommended that the MV (11kV) switchgear, that will be used for this project, be of the metalclad indoor air-insulated type, similar to the locally manufactured ABB Unigear type. This switchgear shall be internally arc rated at the full fault level for up to 1 second.

All protection, metering and control equipment shall be housed in an LV compartment on top of the switchgear panel and not in separate (free-standing panels).

Figure 4-17: Typical Air-Insulated MV Switchgear Panels (Courtesy: ABB)

All circuit breakers shall be fully withdrawable, interchangeable and of the vacuum interrupter type. Circuit breakers shall be rated according to the full load and fault rating requirements as determined during the detail design stage of the project.

It is important to note that the circuit breakers offered shall be of the special type that will allow for up to 30,000 maintenance free operations, to allow for the frequent switching of these breakers required by the implementation of different load shedding schedules.

4.10.8 MV Protection Elements

It is recommended that the protection elements, to be applied on each of the MV feeders, be of the ABB REF615 (Config N) or similar type, which incorporates at least the following specific protection functions (above the usual expected) which is required for Point-of-Utility Connection (PUC) Breakers to comply with Grid Code requirements:

- Under/over voltage
- Under/over frequency
- Rate of change of frequency
- Sync check

4.10.9 Substation Building

Due to the number of MV switchgear panels required, it is recommended that these be installed in a dedicated, brick-built substation building. Typical examples of such a substation building are indicated in the images below.

Figure 4-18: Typical MV Substation Building (External)

Figure 4-19: Typical MV Substation Building (Internal)

The final substation building dimensions and layout will be determined as part of the detail design development of the project.

4.10.10 Standby Diesel Generators

As mentioned in Section 4.9 It is recommended that the backup generators be installed as part of this hybrid solution. It is recommended that two (2) units be installed, which will each be rated 800 kVA (637kWe prime power).

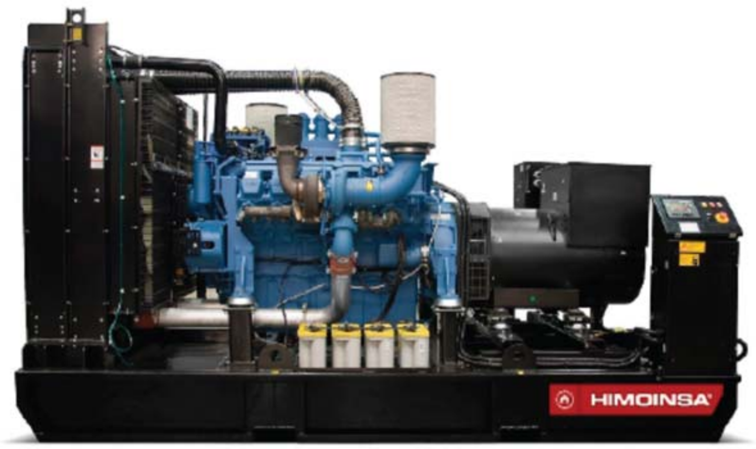


Figure 4-20: Typical 800kVA Diesel Generator Set

It is recommended that both these units be containerised solutions (as per the image below), to be installed on a concrete plinth. Each unit will be equipped with a diesel storage tank in the base of the unit.

Figure 4-21: Typical 800kVA Diesel Generator Set (In container)

Typical fuel consumption values for and 800kVA generator set is provided in the table below.

FUEL CONSUMPTION		
Fuel Consumption ESP	l/h	173,23
Fuel Consumption 100% PRP	l/h	156,64
Fuel Consumption 70 % PRP	l/h	112,28
Fuel Consumption 50 % PRP	l/h	84,09

Table 4-6: Typical fuel consumption values (800kVA set)

4.11 Energy Monitoring and Control System

4.11.1 General

The combined operation of the various sub-systems that make up the proposed hybrid solution is far more complex than operating them individually. In a typical grid-tied system, with only solar energy, just one element needs to be controlled. In a hybrid scheme, all sources (solar, batteries, grid and diesel generators) are to be controlled individually as well as simultaneously, depending upon the operating conditions and energy demand.

During low sunlight conditions, photovoltaic (PV) solar panels cannot supply consistent power. In this case, the other sources need to be structured to make up the lack of energy in conditions when this system does not work regularly, or the composition produces less energy than what is required. The EMS assures that the system works efficiently, whilst preventing the lack of energy in loads. The aim is to provide clean and sustainable energy within a stable frequency and voltage range under all conditions. EMS is important to ensure both economical and efficient operation of the system in combined usage of renewable energy sources. Variable weather conditions, day-night conditions, and rapid change in voltages make this a definite requirement for an optimal hybrid solution.

4.11.2 Topology

It is therefore recommended that a SCADA based energy monitoring and control system be provided as part of the overall solution. A typical example of such a system is provided by ELUM Energy ® and will be used as an example to explain the specific requirements that the system needs to offer.

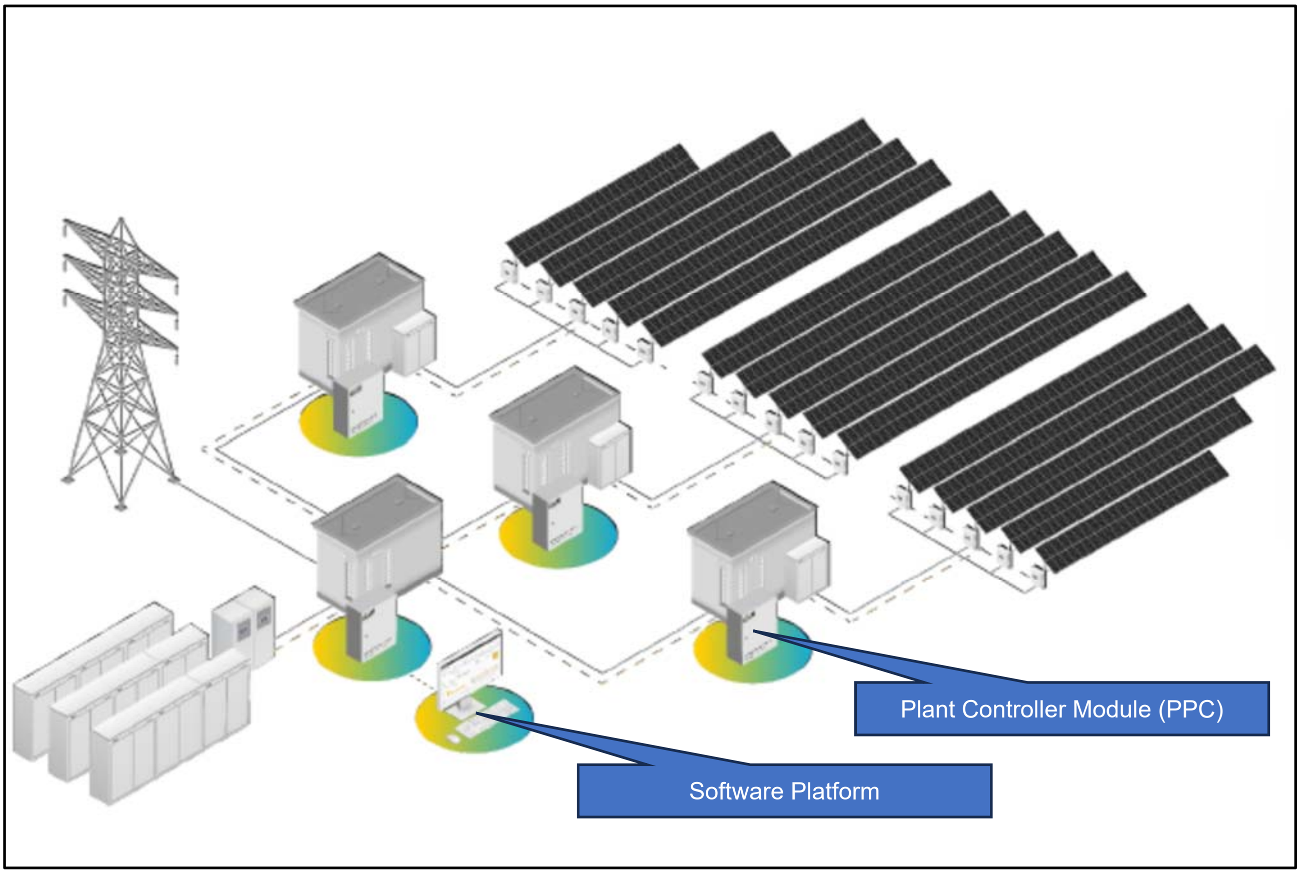


Figure 4-22: Typical EMS Topology (Credit: ELUM Energy)

The main components of such and EMS mainly consist of the following:

Power Plant Controller (PPC) Modules: Cabinet/s installed at the various plant locations to provide PV Solar / BESS / Gensets control with 100% autonomous configuration & operation fitting the following main use cases:

- Grid-tied operation
- Off-grid (islanded) operation

Figure 4-23: Typical Power Plant Controller Module (Credit: ELUM Energy)

The PPC cabinet also houses the RTU and SCADA modules, which allows for the collection of equipment data and statuses, for remote monitoring and control purposes.

Software Platform: Software platform accessible remotely which gathers all the production and automated analysis data of the different plants in order to optimize plant performance.

4.11.3 Functionality

The Energy Monitoring and Control System will incorporate all functions in real time necessary for control and supervision of the PV Plant, Battery Energy Storage System and Diesel Generators. Any other control and surveillance systems (such as fire detection system and security system) shall also be connected to the plant monitoring system. The EMS shall provide at least the following functionality:

- Plant performance tracking.
- Active/reactive power management.
- Reliable data logging from all linked devices, such as meters, solar inverters, ESS, genset controllers, weather stations (irradiance/temperature...), and I/O modules), and offer a secure local storage.
- Simplified plant synoptics.
- Data analysis.
- The possibility to edit setpoints of all linked devices locally from a single interface.
- Customizable alarms.
- Inverter heatmaps, etc.

The EMS shall be able to operate according to the following three (3) different network configurations as presented in the table below:

Configuration	BESS	Gensets	PV Solar	Grid
Grid Prime	Grid Following	Grid Following	Grid Following	Grid Forming
BESS Prime	Grid Forming	Grid Following	Grid Following	Grid Following
Gensets Prime	Grid Following	Grid Forming	Grid Following	Grid Following

Table 4-7: Summary of Plant Configurations

The following functions shall be available when operated in the Grid Prime Configuration:

i. Self consumption
ii. Export control
iii. Peak shaving
iv. Grid reactive power control
v. BESS Time-of-Use Management

The following functions shall be available when operated in the BESS Prime Configuration:

i. BESS charge control
ii. Genset start/stop management

The following functions shall be available when operated in the Genset Prime Configuration:

i. PV optimisation
ii. Genset minimum loading
iii. Genset reactive power control

The following table provides a summary of the functions that will be available from each of the EMS's control subsystems:

Control Subsystem	Available Functions
BESS Control	BESS Ramp Control BESS Charge Control BESS Time-of-Use Management BESS Dispatch Control SoC Equalization
PV Control	PV Ramp Rate Control PV Optimization PV Dispatch Control
Grid Control	Export Control Peak Shaving Grid Reactive Power Control
Genset Control	Genset Ramp Control Genset Minimum Loading Genset Start/Stop Management Genset Reactive Power Control Genset Dispatch Control
Islanding Control	Automatic Black-start Automatic Grid Reconnection

Table 4-8: Available Functions for Control Subsystems

4.12 Weather Station

A fully installed weather station, that is integrated to the onsite SCADA and monitoring equipment, shall be required for the project site. The weather station will be located near the PV module arrays and installed according to the World Meteorological Organisation best practices.

Figure 4-24: Typical Weather Station (Credit: GeoSun Africa)

The purpose of the weather stations will be to record all meteorological parameters required to monitor the Plants' performance.

Pyranometer	
Quantity	For each array's tilt and azimuth angle; 1 in plane of array and 1 on the horizontal plane for PV Plants
Type	Secondary Standard conforming to international standards ISO 9060 and IEC 61724
Range	-40 to +80deg C
Accuracy	±2°%
Location	Installed in the plane of the array with the same tilt and azimuth as the PV modules and shall be adequately located across the site to provide an average measured irradiance that is representative for the site. Shall not be shaded at all times during the year.
Temperature sensors	
Type	Type PT1000 with minimum IP54 protection class
Quantity	1 to measure cell temperature (back of the module) and 1 to measure ambient temperature (shielded ventilated)
Range	-40 to +80°C
Accuracy	±1°C
Location	Module temperature sensor shall be adequately bonded to the module and in the middle of a cell at the centre of the module

Anemometer	
Operational temperature	-20 to 50°C
Speed range	0.5 to 40m/s
Accuracy	Threshold the higher between 0.5m/s or 5%
Location	At the height of the top row of modules

The weather station will be required to log all parameters on a minimum time step of 30 seconds where possible and store integrated parameter values for every 15 minutes.

4.13 MV Cables (AC)

MV cables will be used to interconnect MV equipment: substations, power transformers and MV switchgear. All MV cable installations shall be done with 11/11 kV, Copper, 3-Core, PILC, PVC, DSTA, PVC, (BLK) and manufactured to SANS requirements.

Cable sizes shall be calculated, based on the manufacturer's datasheets, with the required de-rating factors applied for correct sizing of the cables for each specific application.

4.14 LV Cables (AC)

LV AC cables shall be suitable for a solar energy system application. The selection, handling and installation of LV electric cables shall meet the requirements of SANS 10198 Part 1 to Part 14. The LV cables shall be PVC insulated, PVC bedded SWA PVC sheltered 600/1000V cables manufactured to SANS 1507.

Cable sizes shall be calculated, based on the manufacturer's datasheets, with the required de-rating factors applied for correct sizing of the cables for each specific application. A detailed cable calculation spreadsheet shall be provided to the Engineer for approval, based on actual installation conditions, prior to the ordering/installation of any cables.

4.15 LV Cables (DC)

DC cables shall be suitable for a solar energy system application. The selection, handling and installation of electric cables shall meet the requirements of SANS 10198 Part 1 to Part 14.

The positive and negative DC cables will be installed in separate cable trays to prevent electromagnetic coupling between two DC cables of opposing polarities. Cables used for DC circuits will be installed in cable trays attached to the mounting frames.

The interconnection of PV panels will be facilitated with the standard leads and connectors provided with the PV panels. Leads for string cables will be of the Solardac type from the Aberdare cable series (or similar and equal approved).

DC Cabling shall be neatly strapped and each string labelled at the inverter as well as at the starting and ending points of each string. Above-ground cables will be installed to the mounting system using durable fixings in a way that protects them from animals, weather and UV radiation. DC cables will only be installed above ground.

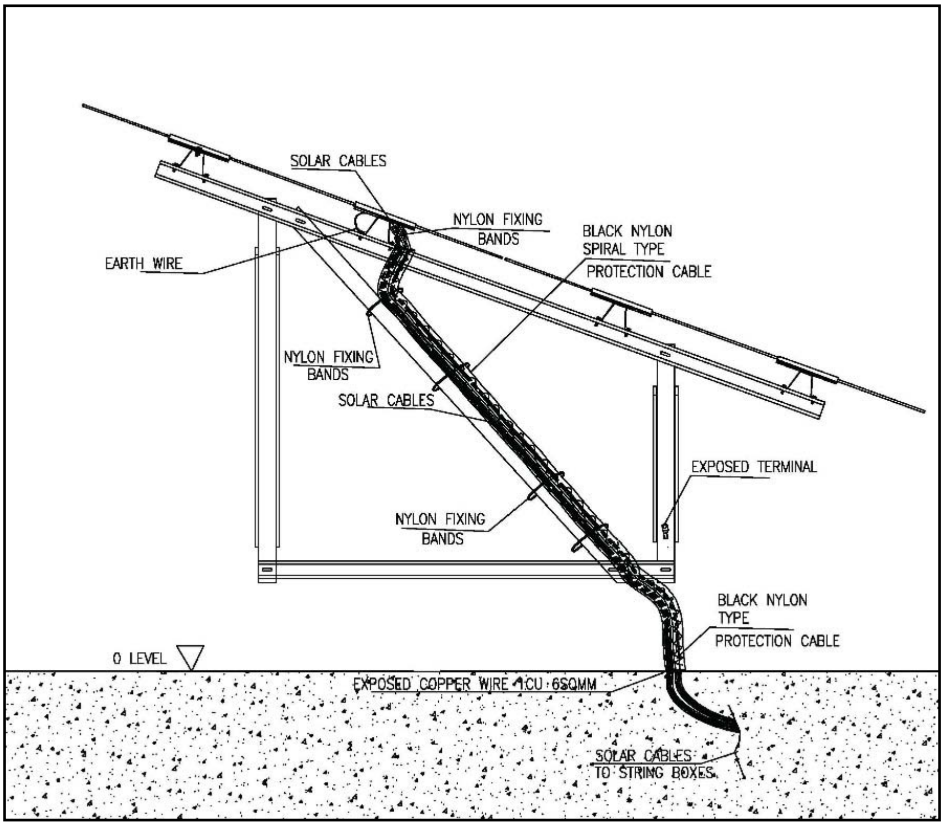


Figure 4-25: Typical Cable Management (Side View)

4.16 Earthing & Bonding

The successful tenderer shall be responsible for conducting earth resistivity tests/ studies to determine the soil resistivity of the proposed PV field installation area. The information will be applied to design an earth mat that will give an adequate earth reading.

The Contractor shall be made responsible for the design, supply and installation of an earth mat based earthing system for the ground mounted PV Plant that eliminates the risk to personnel or animals of electric shock under normal operating conditions as well as fault conditions.

An effective earth mat system shall be designed and installed as part of the overall installation, which shall prevent dangerous over voltages arising between metallic structures, frames, supports or enclosures of electrical equipment and the ground during fault conditions. An effective earth mat shall be able to permit fault currents of sufficient magnitude to flow to operate protective devices to isolate the fault before damage can occur. The earthing system will also be designed with the design of the lighting protection taken into consideration.

An earth mat, typically consisting of 10mm² solid copper conductor, will be required on the platform on which the PV panels and mounting structures will be installed. Joints in earth bars shall preferably be brazed or exothermally welded.

The solar photovoltaic generator (solar module array, mounting structure and inverters) will be bonded to the underground earthing network by means of insulated earth conductor installed in galvanized water pipes, where applicable.

Copper rods 16mm² in diameter and 1500mm in length will be used in conjunction with the earth mat to obtain an earth resistance reading of less than 2 ohm.

Inverters, transformers, minisubs as well as all MV and LV switchgear should also be bonded to the same earthing network to ensure the safety of personnel and maintenance workers during fault conditions.

The Contractor shall be responsible to provide an earth mat design proposal including but not limited to:

- A project specific earthing system diagram.
- An earth mat simulation model, using CDEGS or CYMGRD (or other similar approved) software package, to calculate the maximum expected step-and-touch potentials and earth potential rise for the overall site, based on the soil models obtained from the actual earth resistivity measurements.

4.17 Surge & Lightning Protection

The successful tenderer will be required to perform a lightning risk assessment study to determine the requirements for an adequate lightning protection system. The Contractor shall design the Lightning Protection system in accordance with the latest edition of the SANS/IEC 62305 standards.

The lightning protection system will protect the plant, inverters, control and monitoring systems and any other electrical and mechanical equipment against damage caused by lightning strikes. Contractor will submit proposals to The Engineer for ensuring adequate design against lightning induced overvoltage risk prior to installation.

Overvoltage protection will be installed at the DC side as well as AC side of the inverter and within the PV arrays. In general, the design of the DC system must ensure that cables are kept in parallel and as short as possible, while cable loops are also avoided or restricted. Protection against direct strikes (direct strike lightning protection) will be installed and coupling as a result of strikes elsewhere in the grid (indirect strike lightning protection) will be taken into consideration and designed out of the system.

Supplementary earthing and bonding will be provided throughout the facility with bonding of PV module mounting system, inverters, cable containment and wire ways (and any other extraneous metalwork), including bonds to lighting masts air termination network at suitable intervals with the aim of achieving equipotential of the entire installation.

5 PRELIMINARY DESIGN: CIVIL

5.1 Background

This chapter will detail and discuss the preliminary civil engineering services design of the proposed development in terms of firstly the bulk engineering services and secondly the internal engineering designs in parallel with the engineering standards and technical design criteria applicable to the project.

A number of pre-application meetings have been held with officials of various relevant municipal departments to discuss the development as well as the requirements for the application submission.

5.2 Terms of reference

The terms of reference for the civil works on the project shall include at least the following, but may be expanded during the detail design stage:

- Earthworks
  - Mass earthworks (cut and fill)
  - Mass earthworks (modification)
  - Layerworks
  - Trench excavations
  - Compaction
  - Platforms
- Foundations
  - Concrete plinths
  - Drilled foundations
  - Rammed-in foundations
  - Building foundations
- Structures
  - Structural steel
  - Buildings
- Stormwater
- Roads
- Civil services
  - Water
  - Sewer
  - Sleeves
- Solid waste
- Security fencing
- Minor and incidental civil works

5.3 Site Assessment

An assessment of the site has been performed in line with the following criteria. These assessments will be expanded upon during the detail design stage:

- Topographical survey – to be performed during the detail design stage.
- Cadastral limits of the site – to be obtained during the detail design stage.
- Evaluation of the topography – discussed in this report and will be expanded upon during the detail design stage.

- Environmental Impact Assessment (EIA) – An EIA consultant/specialist has been appointed and the EIA process is underway. All necessary environmental aspects will be covered in detail during the EIA process.
- Permits and wayleaves - All necessary permits and wayleaves will be investigated and obtained during the detail design stage.
- Geotechnical investigation – A visual geotechnical investigation has been included in this report while a detailed geotechnical investigation will be commissioned as part of the detail design stage.
- Stormwater – A stormwater management plan has been included in this report and will be expanded upon during the detail design stage.
- Earthworks – A preliminary discussion is presented in this report and will be expanded upon during the detail design.
- Services – A discussion on existing civil services, i.e. water and sewer, is presented in this report.
- Roads and access – a discussion is presented in this report.
- Solid waste – a discussion is presented in this report.
- Security fencing – a discussion is presented in this report.

5.4 Topographical Survey

A topographical survey will be commissioned in due course as part of the detail design stage. The topographical survey will include the following aspects:

5.4.1 Survey Extents

The extent of the survey must cover the following:

- The survey must extend a minimum of 50m beyond the facility boundary lines.
- Survey (where applicable) the existing road including kerb and road centreline 50m beyond the extent of the Erf boundary lines. Indicate vehicle entrances, existing parking areas and pedestrian paths.
- Spot levels in the road servitudes (where applicable) to determine general storm water flow directions.

5.4.2 Survey Requirements

The survey must be suitable for the design of all the services as well as the bulk earthworks and must cover at least the following:

- Spot levels on the site to be taken at maximum 10m intervals to produce a detailed contour survey with 0.25m contours.
- Position and ground levels of existing fences, boundary walls and structures to be indicated.
- Position of trees to be indicated in plan.
- Rock outcrops to be indicated in plan.
- The position and levels (cover and invert where applicable) of all visible services. The services include electrical (light poles and overhead power poles), water, sewer (Manholes), storm water (Manholes) and telecommunication.
- All break lines to be indicated clearly. Break lines will be surveyed for top and bottom of embankments, the rock outcrops, storm water channels and road edges. These break lines will be indicated on a separate layer on the DWG drawing file of the completed survey.

- Establish at least 4 benchmarks on the site fixed in concrete in a position that will not be disturbed by construction, just on the outside of the road or close to the fence on the inside. The benchmarks should be visible from any point on the site.
- Provide coordinates and levels above sea level for each benchmark. The benchmarks should be clearly marked in the concrete or with any other permanent method, except using manhole covers for reference.
- The survey is to be done in the relevant WGS84 system and the levels to be in meters above sea level (MLS). The local WGS84 system to be indicated on a .dxf or AutoCAD .dwg drawing file.
- The survey grid with the grid values to be included on the survey drawing.

5.4.3 Benchmarks (Reference Points)

Benchmarks (reference points or specific markers) must be established on site to serve as a consistent and reliable basis for measurements, elevations, and alignments during construction or engineering activities. In the context of ground preparation for a solar PV project, establishing reference points involves identifying and marking key locations on the site that will be used as a guide for various tasks, such as:

- Grading
- Levelling
- Placement of struts
- Placement of the structures
- Aid in the finalisation of the shading distance between tables.
- These reference points help ensure accuracy, consistency, and adherence to the project design and specifications.

The reference points can be established using surveying techniques and equipment, such as:

- Total stations
- GPS receivers
- Laser levels
- Ground control points
- The chosen method depends on the precision and requirements of the project.

Once the reference points are set, they provide a framework for subsequent measurements and construction activities, allowing for precise positioning, alignment, and elevation control. They serve as a common reference for different teams or contractors working on the project, ensuring that everyone is working based on the same set of coordinates and measurements.

5.4.4 Deliverables

The following deliverables are required from the survey:

- The information to be provided electronically in .dxf or dwg format. The YXZ ASCII files of the points and the break lines are also required with an explanation of the codes used. The DXF file shall indicate all break lines. Also include a separate DWG file with all the 3D triangles required to generate the contours.
- The survey drawing to include all cadastral information (erf boundaries, road reserves and servitudes) for the surveyed area, as indicated on the SG diagrams.
- The list of benchmarks installed by the surveyor as part of the survey, with their coordinates and their levels.
- List of trig beacons used to establish the benchmarks.

5.5 Geotechnical Investigation

A formal geotechnical investigation has not been performed yet and will be commissioned in due course during the detail design stage. A visual inspection of the site was conducted in order to assess conditions on site. The following discussions are relevant for preliminary design stage:

5.5.1 General soil profile

The complete site is disturbed and covered with partially overgrown grit stockpiles from the WWTW operations. Minor modifications would be required with commercial fill material.

5.5.2 Topography

The site is defined by a single gentle side slope to the south of approximately 7 - 12%.

5.5.3 Drainage

The study area is drained mainly by means of surface run-off (i.e.: sheetwash), with storm water following the topography of the site, i.e. the side slope.

5.5.4 Surface drainage

An efficient surface drainage system shall be ensured around all structures and along all roads throughout the study area in order to prevent the ponding or accumulation of water next to structures or roads.

5.5.5 Sub-surface drainage or cut-off drain

Sub-surface drainage may be considered around the upper perimeter in order to drain subsurface water away from the site prior to entering the site. This may also be achieved with a cut-off drain on the upper perimeter.

5.5.6 Slope Stability

Gradients on the site is flat to undulating. No natural slope instability is present.

5.5.7 Ground water and stormwater

No ground water and/or perched water are evident. A low to moderate water retention rate is expected. Lateral movement of stormwater will be moderate due to the flat to undulating gradient. Erosion of the silty sands may occur.

5.5.8 Engineering Services

A TLB will suffice for trenching and excavations of all services and all infrastructure. Although the possibility of rock is deemed to be small, rock may be present at deeper depths. This will be determined by a formal geotechnical investigation.

5.5.9 Foundations for mounting structures

The visual investigation indicated that the in-situ materials will have to be modified with commercial fill material to be utilized for foundations. The specification for the commercial fill will be determined from the formal geotechnical investigation and subsequent detail design.

5.5.10 Foundations for buildings

The visual investigation indicated that the in-situ materials will have to be modified with commercial fill material to be utilized for foundations for buildings. The specification for the commercial fill will be determined from the formal geotechnical investigation and subsequent detail design. Reinforced raft foundations will be utilized in combination with reinforced strip footings where required.

5.5.11 Construction materials

A number of commercial operators are located in close proximity to the site for the provision of imported construction materials.

5.5.12 Formal geotechnical investigation

A formal geotechnical investigation has not been performed yet and will be performed during the detail design stage. A thorough geotechnical investigation, covering the entire area where the mounting structures will be installed will be conducted. The information obtained from the study will be used to determine which amount of the footings from the PV mounting arrays will be rammed-in, drilled or will require concrete foundations.

The terms of reference for the geotechnical investigation shall include at least the following:

- Detailed soil profiles, Dynamic Probe Light (DPL) profiles and laboratory certificates
- Regional geology and soil profile summary
- Assessment of the ground water and bedrock conditions
- Assessment of the soil density/consistency with depth
- Identify any problematic soils
- Provide recommendations regarding the founding level and estimated bearing capacity

5.6 Soil Thermal Resistivity Measurements

The thermal resistivity (T/R) and stability of soil are important factors in the determination of the current ratings of underground cables. The lower the thermal resistivity of the soil, the higher the rate of heat discharge from the cable. Conversely, the higher the thermal resistivity of the soil, the greater the rise in temperature of the cable due to the lower rate of heat discharge through the soil.

When the cable continuously operates at a temperature above its design value, undue aging takes place, increasing fault frequency and reducing cable life. When the thermal resistivity of the soil is high, cables shall have to be so derated that the cable temperature does not exceed the design value. Alternatively, cables of larger conductor size may be used.

The thermal resistivity of a soil is a measure of the resistance of the soil to the flow of heat and its value is inversely related to the moisture content of the soil. When electric cables are continuously operated at sheath (surface) temperatures of 55°C or above, the moisture in the soil surrounding the cable may migrates away from the cable, leading to an increase in the thermal resistivity of the soil locally and consequent increase in the cable conductor temperature. This leads in turn to a further increase in the surface temperature of the cable. Steady state conditions are eventually achieved with the cable operating at a conductor temperature higher than its design temperature.

This will not result in immediate failure of the cable but will reduce its life expectations. In the SI system of units, thermal resistivity shall be measured in K.m/W. The measurement of the thermal resistivity of soil can be carried out in a laboratory or on site. Laboratory methods are cheaper but might not recreate site conditions, and on-site methods are subject to the weather and the skill of the operator of the apparatus.

Thermal resistivity testing (TR Testing) shall be carried out on both natural soils and specifically designed quarried products that will be used for MV cable installation and/or backfilling of trenches to determine the material's thermal characteristics and how well they conduct heat away from the underground cable installation.

When testing natural soils, samples collected from site locations shall be progressively dried and tested to establish the thermal resistivity versus moisture content relationship. This dry out curve is of particular use if the native soil around a cable partially dries out under cable operating temperatures.

When testing quarry products to determine their thermal suitability as cable backfill or bedding a variety of methods can be adapted depending on the nature of the product and specification requirements.

The thermal resistivity of the natural soil and backfill material shall be done in accordance with SANS 10198-4:2004 and the results will be used as input to the de-rating factors to be used as part of the MV and LV cable installations.

5.7 Soil Resistivity Measurements

The resistance of an earth electrode is related to the resistivity of the soil in which it is placed and driven, and thus soil resistivity calculations and measurements is a crucial aspect when designing earthing installations. Electrical resistivity is the measurement of the specific resistance of a given material. It is expressed in ohm-meters and represents the resistance measured between two plates covering opposite sides of a 1 m cube.

This soil resistivity test is commonly performed at raw land sites, during the design and planning of grounding systems specific to the tested site. Soil resistivity testing is the process of measuring a volume of soil to determine the conductivity of the soil.

Soil resistivity testing is the single most critical factor in electrical grounding design. This is true when discussing simple electrical design, to dedicated low-resistance grounding systems, or to the far more complex issues involved in Ground Potential Rise Studies (GPR). Good soil models are the basis of all grounding designs and they are developed from accurate soil resistivity testing.

The Contractor shall perform an on-site Soil Resistivity Measurement for at least three (3) different locations within the project area to get a good average of the overall soil conditions, using any one of the following methods:

- Wenner Array Method
- Schlumberger Array Method
- Driven Rod Method.

5.8 Environmental Impact Assessment (EIA)

An EIA consultant/specialist has been appointed and the EIA process is underway. All necessary environmental aspects will be covered in detail during the EIA process. This preliminary design report will be a major input into the EIA process.

5.9 Earthworks

Earthworks will form a major part of this development and it is crucial that all aspects surrounding earthworks are thoroughly addressed during the detail design stage. The following aspects will be considered:

5.9.1 Clearing and Excavation

Clear the site of vegetation, debris, and obstacles that could interfere with the grading process. Perform necessary excavation to remove unwanted material or achieve the desired grading level.

5.9.1.1 Vegetation Removal

- Clear the site of trees, shrubs, grass, and any other vegetation that may interfere with the solar PV system installation or cast shadows on the panels.
- Remove the root systems or treat the area to prevent regrowth. Where the roots of trees, have been removed it is critical to follow the compaction requirements mentioned later in the document.

5.9.1.2 Debris and Obstacle Removal

- Clear the site of any debris, rocks, construction materials, or other obstacles that could hinder the installation process or pose a safety risk.
- Properly dispose of the cleared materials following local regulations and project requirements.
- Excavate the area using machinery such as excavators or bulldozers to remove unwanted material or create a suitable foundation for the solar PV system.

5.9.1.3 Soil Preparation

- Evaluate the soil conditions and make necessary adjustments during the excavation process to ensure a stable foundation.

5.9.1.4 Erosion Control

- Implement erosion control measures during the clearing and excavation process to prevent soil erosion and sedimentation.
- Use erosion control blankets, sediment barriers, or other erosion control techniques to minimize environmental impact if necessary.

5.9.1.5 Storm Water Management

- During the excavation and clearing, a storm water management plan must be implemented. Water must be moved off the solar PV site in a manged way to facilitate easier construction as well as ensure foundation are not compromised over time.
- Implement appropriate drainage features including but not limited to, French drains, cut away drains, gentle slopes, or swales in order to facilitate water movement away from the PV system, preventing pooling or erosion.
- Building roads, fences, or any other services on the site should be mindful of the impact on the drainage of the site.

5.9.2 Mass earthworks

Mass earthworks (cut and fill) will be required on this site to obtain a uniform and workable platform for the installation.

Compaction will be in 150mm layers to ensure compliance to the compaction density. The compaction process ensures soil stability, load-bearing capacity, and reduces the potential for settlement or unevenness over time.

5.9.2.1 Compaction Equipment

- Utilize compaction equipment such as vibratory rollers or plate compactors suitable for the soil type and project scale. Select equipment with appropriate compaction force and compaction plate size to achieve desired compaction results.

5.9.2.2 Layer Material

- A G5 fill material is recommended.

5.9.2.3 Layer Thickness

- Compact the base where the impediment has been removed.
- Then compact the soil in layers with a maximum gauge of 150mm.
- Each layer should be uniformly compacted before proceeding to the next layer.
- The process must be repeated until natural ground level (NGL) has been met.
- Failure to adhere to the process may result in the compromising of the pile foundations over time.

5.9.2.4 Moisture Content

- Ensure the soil moisture content is within the specified range for optimum compaction.
- If the soil is too dry, moisten it using water to achieve the desired moisture content.
- If it is too wet, allow it to dry or add dry soil to adjust the moisture level.

5.9.2.5 Compaction Method

- Apply compaction equipment evenly across the surface of each layer.
- Use a combination of overlapping passes to achieve uniform compaction throughout the layer.

5.9.2.6 Compaction Density

- 95% Mod AASHTO.
- The specific compaction density requirements may vary depending on project specifications and soil characteristics.

5.9.2.7 Quality Control

- Regularly monitor and test the soil compaction during the process to ensure compliance with the specified compaction requirements.

5.9.2.8 Documentation

- Maintain records of compaction tests, including test results, equipment used, and the depth or thickness of each compacted layer and GPS location of the areas of compaction when localised.

5.9.3 Grading Plan

Solar PV sites, aside from clearing and excavation, will also require grading to ensure consistency across the site. Grading tolerances for fixed tilt solar PV mounting structures can vary based on project-specific requirements and industry standards. However, for the specific requirements outlined below, the following tolerances are recommended:

5.9.3.1 Elevation Variation

- Ensure a maximum tolerance of around -100mm- +100mm for elevation variation across a single table. This tolerance accounts for variations in the ground elevation from the specified target elevation.

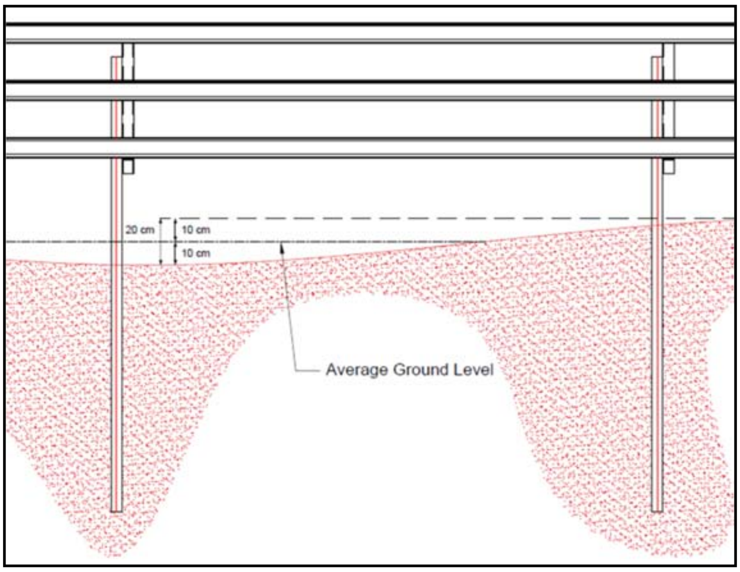


Figure 5-1: Typical Soil Elevation Variation Limits

5.9.3.2 Grading Uniformity

- Aim for a consistent slope within the project specifications considering the specified 0-3 degrees tolerance in the east-west direction and 0-5 degrees tolerance in the north-south direction, the maximum allowable deviation from the desired slope should not exceed these angular tolerances.

5.9.4 Quality Control

- Regularly inspect the grading work to verify adherence to the grading plan and required specifications.
- Employ surveying tools and techniques to ensure accuracy of grading levels and slopes.

5.10 Water

A brief discussion on bulk and internal water will be presented in this chapter and will be expanded upon during the detail design stage.

5.10.1 Water Demand and Availability

The Average Annual Daily Demand (AADD) for this proposed development will be less than 1kl/day and is deemed negligible from a design- and decision making perspective. Bulk water is available for this development.

Washing of the PV Solar panels will be performed by tanker with treated effluent from the WWTW, hence no potable water will be utilized for this maintenance item.

5.10.2 Connection Point

The site will be serviced via the existing water infrastructure from the Hartenbos Regional WWTW.

5.10.3 Design Criteria and Standard of Engineering Services

The design criteria and standard of engineering services for the project will be as follows:

- Design consumption
    - o Industrial buildings – 100l/100m^{2}GLA/day
- Peak factors as prescribed
- Minimum pressures for the network are calculated for a fire flow 30l/sec and peak demand at the point of lowest pressure under peak conditions.
- Maximum of 4 valves to isolate a pipe section.
- Maximum length of 600m of main pipe per isolated section.
- Air valves to be provided where applicable.
- Minimum cover to pipes to be 900mm.
- Pipe type and class to be uPVC class 6 to 12, depending on existing network pressure.
- Pipe diameters as required depending on pressure available and flow required.
- Fire hydrants to be provided in accordance with relevant guidelines and legislation.

5.10.4 Design

The design drawing will be finalised during the detail design stage and is not relevant for this stage of the project.

5.11 Sewer

A brief discussion on bulk and internal sewer will be presented in this chapter and will be expanded upon during the detail design stage.

5.11.1 Design flow

The Average Dry Weather Flow (ADWF) of the development will be less than 1kl/day and is deemed negligible from a design- and decision making perspective.

5.11.2 Connection Point

No new sewer infrastructure will be constructed for this development. All sewer generated will be through the existing infrastructure at the Hartenbos Regional WWTW, i.e. existing offices and ablutions.

5.11.3 Capacity at Hartenbos Regional WWTW

The existing Hartenbos Regional WWTW has sufficient capacity to accommodate the additional demand generated by this development.

5.11.4 Site Layout Considerations

As no new sewer infrastructure will be developed for this proposed development, the site layout is not a consideration.

5.11.5 Design Criteria and Standards of Engineering Services

As no new sewer infrastructure will be developed for this proposed development, design criteria and standard of engineering design are not considerations.

5.12 Roads and access

5.12.1 Access

Access to the site will be via the Hartenbos Regional wastewater treatment works (WWTW), which in turn obtains access from the R102 (MR344) via a security controlled access gate. Access to the PV Solar site will be on the north-western corner of the Hartenbos WWTW. Access is depicted on the following diagram.

Figure 5-2: Access to the proposed development from the Hartenbos Regional WWTW indicated in red.

5.12.2 Internal roads

An internal access and perimeter road network will be provided. The access road will be provided from the north-western corner of the existing WWTW and will be paved up the solar MV station. The remainder of the perimeter and internal roads will be gravel. The preliminary design is presented in the following diagram.

Figure 5-3: Access road and internal perimeter roads

5.12.3 Internal Standards and Design Criteria

Internal standards and design criteria are specified as follows:

- Internal road widths of access road – 4m; perimeter and other roads – 3m
- Access road surfaced with interlocking paving; all other roads gravel wearing course.
- Pavement structural materials to be imported from commercial sources.
- All minimum radii at bell mouths to be 8m.
- Minimum road grade of 0.4% and camber of 2%.
- Road design life of 20 years.

5.13 Traffic Impact Statement

Peak hour (morning and afternoon) trip generation from operation and maintenance personnel is estimated at less than 5 trips. The traffic impact of the proposed development will be negligible from a traffic engineering perspective.

5.14 Stormwater management plan

A stormwater management plan is presented in this chapter.

5.14.1 Design background

Stormwater technical design on this development is relatively uncomplicated due to the development being situated on a single gentle side slope of approximately 7 - 9% and hence only a single and simply defined drainage zone. Stormwater from the single drainage zone will drain into the existing stormwater channel on the western boundary of the existing WWTW site, which again drains into the Hartenbos lagoon on the south-western boundary of the site.

5.14.2 Design considerations

Stormwater design on this proposed development is notable not only from an engineering perspective but also from an environmental perspective due to the close vicinity to the Hartenbos lagoon.

Environmental design will make use of Sustainable Drainage Systems (SuDs) to manage stormwater within close proximity to the lagoon. SuDs will assist in preventing significant impact on the hydrological functioning of the lagoon and reduce the risk of erosion. SuDs vegetated with indigenous species can assist with water polishing, trapping hydrocarbons from stormwater runoff from the development area before this is released into the lagoon.

Although the proposed development does not propose to concentrate stormwater in any manner, notwithstanding, wherever stormwater is concentrated during the implementation phase, energy dissipation shall be performed as standard practice with gabion mattresses where required. Consideration shall be given during the detail design stage to using materials with high roughness in order to further assist with energy dissipation. This will further prevent erosion and improve habitat provision.

5.14.3 Freshwater Habitat Compliance

Freshwater habitat compliance shall be contemplated as the proposed development is adjacent, albeit quite a distance, from the lagoon. Freshwater compliance concepts are discussed in this chapter and, where relevant, imported into the stormwater management plan.

5.14.3.1 Introduction

The mitigation of negative impacts on biodiversity and ecosystems is a legal requirement. Its application is intended to strive to first avoid disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided altogether, to minimize, rehabilitate, and finally offset any remaining significant residual negative impacts on biodiversity.

Any potential risks must be managed and mitigated to ensure that no deterioration to the water resource takes place. Management measures should be implemented to ensure that no activities result in a decline in water resource quality.

Monitoring for compliance must be done on a daily basis by the contractors. Photographic records of all incidents and non-compliances must be retained. Monitoring should especially focus on preventing water pollution, avoiding riparian habitat, and determining the success of the stormwater management plan.

5.14.3.2 Evidence of wetland, drainage line or watercourse

The site was inspected for evidence of a wetland, drainage line, or any other watercourse. The development area is in a disturbed state, vegetated by a selection of grasses and other vegetation. The site is defined by a single gentle side slope of between 7 and 9%. Due to the flat gradient on the site with no catchment area, there is little opportunity for significant runoff to accumulate or flow paths to form on the site.

5.14.3.3 External drainage lines

The study area is drained by means of surface run-off (i.e.: sheetwash), with storm water following the topography of the site, i.e. the side slope. The Hartenbos lagoon is on the south-western boundary of the site and all sheetwash drains into an existing channel which drains into the lagoon. The lagoon has riparian vegetation in comparison to the terrestrial vegetation on the proposed development site.

5.14.3.4 Buffer zones

Aquatic buffer zones are provided to act as barriers between human activities and sensitive water resources in order to protect them from adverse negative impacts. Buffer zones associated with water resources have been shown to perform a wide range of functions and have therefore been adopted as a standard measure to protect water resources and associated biodiversity. An aquatic buffer zone is defined as a zone of vegetated land designed and managed so that sediment and pollutant transport carried from source areas via diffuse surface runoff is reduced to acceptable levels.

The development site is located approximately 730m from the lagoon and a buffer zone is hence not required or defined for this project.

5.14.3.5 Stormwater design considerations

Designs must provide due consideration to the appropriate ecological input and be based on Sustainable Drainage Systems (SuDs). Permeable infrastructure must be considered where practical. This may include items such as permeable concrete block pavers, stone, gravel and grass cover. Soft and porous infiltration layers must be provided and will contribute to slowing surface flows. This may include a.o. gabion matrasses where required. Gradients of such infrastructure, e.g. gabion mattresses to be designed as flat as possible. This will provide filtration, removal of urban pollutants (e.g. hydrocarbons), provide attenuation, and dissipate energy of storm water flows through increased roughness.

Stormwater accumulation shall be prevented as far as possible. Stormwater infrastructure, such as gabion mattresses, must be located within the development footprint and not encroach into the buffer area.

Stormwater systems must trap any additional suspended solids and pollutants originating from the development.

5.14.3.6 Post-construction rehabilitation phase

Post construction rehabilitation activities to all disturbed areas shall include the following:

- The area must be maintained through alien invasive plant species removal and the establishment of indigenous vegetation cover to filter run-off before it exists the site.
- All post-construction building material and waste must be cleared and disposed of in a suitable manner and areas rehabilitated.
- Removal of vegetation must only occur where required for the project and disturbance to the adjoining natural vegetation cover or soils is not allowed.
- Erosion features that have developed are to be stabilized and rehabilitated.
- A monitoring programme shall be in place to monitor any post-construction environmental issues and impacts such as increased surface runoff.
- All disturbed areas shall be rehabilitated and maintained.

5.14.3.7 Operational Phase

Any evidence of erosion from the stormwater system must be rehabilitated and the volume/velocity of the water reduced through further structures and/or energy dissipaters. These structures must be incorporated within the layout area.

5.14.4 Site layout considerations

Stormwater technical design on this development is relatively uncomplicated due to the development being situated on a single gentle side slope of approximately 7 - 9% and hence only a single and simply defined drainage zone.

The study area is drained by means of surface run-off (i.e.: sheetwash), with storm water following the topography of the site, i.e. the side slope. Stormwater from the single drainage zone will drain into the existing stormwater channel on the western boundary of the existing WWTW site, which again drains into the Hartenbos lagoon on the south-western boundary of the site.

No stormwater accumulation and concentration will be performed or allowed on the proposed development footprint.

The designated drainage zone as identified above are indicated diagrammatically on the figure below:

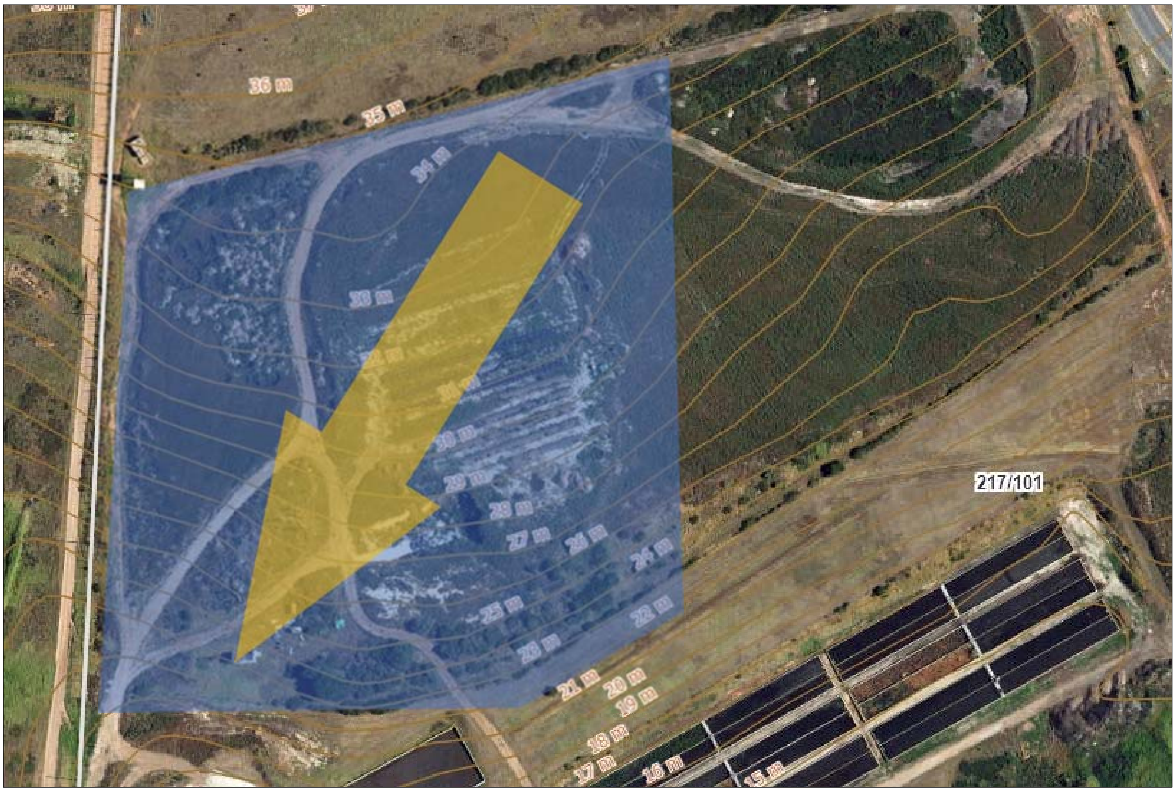


Figure 5-4: Single stormwater drainage zone (zone A)

5.14.5 Stormwater technical design

Stormwater technical design on this development is relatively uncomplicated due to the development being situated on a single gentle side slope of approximately 7 - 9% and hence only a single and simply defined drainage zone. The study area is drained by means of surface run-off (i.e.: sheetwash), with storm water following the topography of the site, i.e. the side slope. Stormwater from the single drainage zone will drain into the existing stormwater channel on the western boundary of the existing WWTW site, which again drains into the Hartenbos lagoon on the south-western boundary of the site. No stormwater accumulation and concentration will be performed on the proposed development footprint. The technical stormwater design on the project is however still critical to consider as part of the stormwater management plan.

5.14.5.1 Drainage zone A

Approximately 100% of the site drains towards a general south-western direction towards the lagoon. This area is designated as Zone A as depicted above.

Zone A has an area of approximately 2.5ha with an estimated 1:2 year peak flow of 0.162m3/s and 1:50 year peak flow of 0.462m3/s and will be routed via unconcentrated sheetwash (surface run-off) into the existing stormwater channel on the western boundary of the existing WWTW site, which again drains into the Hartenbos lagoon on the south-western boundary of the site.

5.14.5.2 Energy dissipation

Energy dissipation shall be performed throughout the site with grass cover throughout, and porous materials wherever required. The site shall be covered with an indigenous grass mix and all post construction erosion or disturbed areas shall be sown with such a mix accordingly.

5.14.5.3 General design criteria

In accordance with all the design philosophies discussed above, the following general design criteria shall be utilized for this proposed development:

- No obstruction or concentration allowed on site.
- Perimeter road layout to be designed to line up with NGL.
- Perimeter road cross-section to be designed to tie into NGL.
- No obstruction or concentration allowed on fencing design, stormwater shall be allowed to pass through fence without any concentration.
- No obstruction or concentration allowed on pile-driven or other supports.

5.14.5.4 Stormwater design drawings

The diagrams below indicate the stormwater design drawings and the external drainage routes on the proposed development as discussed above.

Figure 5-5: No stormwater obstruction or concentration on site, roads to be designed to line up with NGL.

5.14.5.5 Perimeter and internal roads

Design of perimeter and internal roads is intertwined with stormwater design and from an engineering perspective, are considered a part of stormwater design. Internal standards and design criteria for internal street design, relevant to the stormwater management plan, are specified as follows:

- Internal road widths as specified.
- Gravel wearing course.
- Longitudinal alignment to align with NGL.
- Crossfall to align with NGL on both sides.
- No kerbing, or non-protruding concrete edging, to allow for cross section drainage.

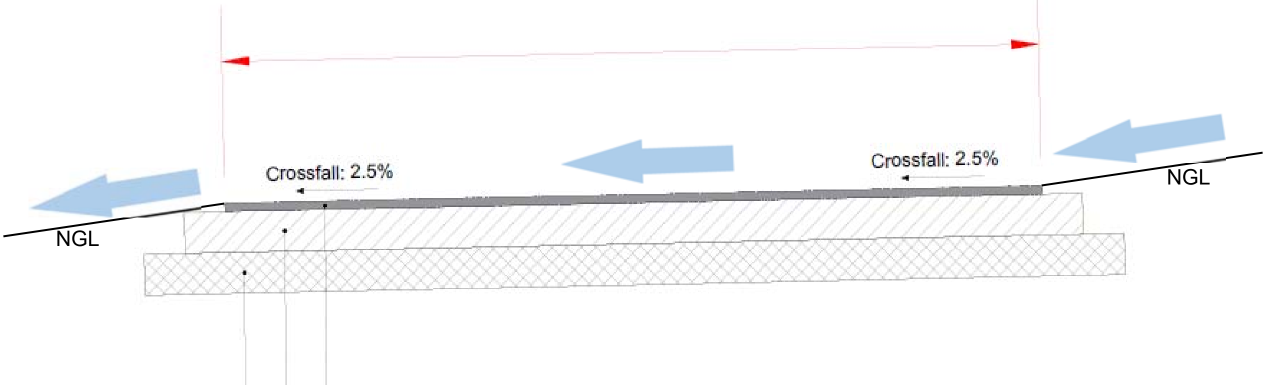


Figure 5-6: No obstruction or concentration on road cross-section – to be designed to tie into NGL.

5.14.5.6 Other design standards and criteria

- Kerbs, channels, pipes or cut-off drains to be utilized as little as possible
- Where kerbs or concrete is inevitable, non-protruding designs shall be utilized.
- Gabion (reno) mattresses to be provided wherever required for energy dissipation and erosion protection.
- All infrastructure on the project to be non-erosive and non-concentrating.
- All stormwater infrastructure to be designed on SuDs principles.
- Soft and porous infiltration media to be provided throughout the site.

5.14.6 Final designs

All final design for stormwater systems and structures on this project to be designed by a professional engineer in accordance with this stormwater management plan.

5.15 Foundations and Structures

This chapter will discuss the preliminary design of the foundations and structures for the PV Solar array as well as the buildings for the project.

5.15.1 Foundations: PV Solar Array

The foundations of the PV Solar Array will be any one or combination of the following and will be determined during the detail design from the geotechnical investigation:

- Concrete plinths
- Drilled foundations
- Rammed-in foundations

5.15.2 Structure: PV Solar Array

The structure of the PV Solar Array will be a light steel frame structure and may take a number of forms, depending on the eventual detail design. A typical structure is presented in the following diagram:

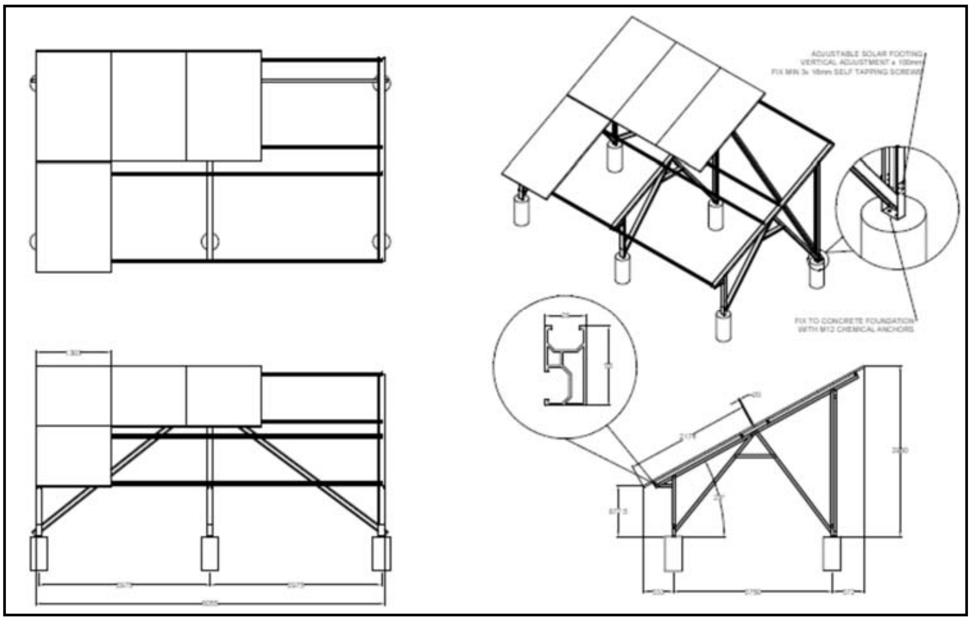


Figure 5-7: Typical PV Mounting Structure

5.15.3 Foundations: Buildings

A number of buildings are foreseen for this project and include the following:

- Substation
- Battery and generator station
- Solar MV station

The localities of these buildings are indicated in the following diagram as extract from the SDP:

Figure 5-8: Substation (orange), MV Solar station (red) and Battery/generator station (purple and yellow)

The foundations of all buildings will be concrete raft foundations and will be finalised during the detail design based on the geotechnical investigation.

5.15.4 Structure: Buildings

The superstructure of the buildings will be as follows:

- Substation – Facebrick with IBR roof
- Battery and generator station – Steel frame with IBR roof
- Solar MV station – Steel frame with IBR roof

All structural designs will be finalised during the detail design stage.

5.15.5 Design Criteria and Standard of Engineering Services

The design criteria and standard of engineering services for the project will be as follows:

- All designs within various relevant SANS specifications
- Building foundations to be concrete raft foundations
- PV Solar Array foundations to be concrete plinths, drilled or rammed
- All foundation to be on engineered fill to at least 150kPa bearing pressure
- All mechanical and fire designs to be confirmed during detail design stage and in line with relevant guidelines and legislation

5.16 Solid Waste

A formal solid waste collection area will be provided as part of the solid waste system of the existing WWTW, and be collected in line with this arrangement.

5.17 Security Fencing

A high security fence (Clearvu or similar) shall be provided for the full perimeter in accordance with the SDP and shall conform to all prescribed coastal standards. Installation shall be performed strictly in accordance with the manufacturers specifications. A concrete security ground beam shall be provided.

6 BUDGET COST ESTIMATE

HARTENBOS WWTW - PV SOLAR & BESS: BUDGET ESTIMATE		
Item	**Description**	**Estimate**
1	**CIVIL WORKS & STRUCTURES**	
1.1	SITE CLEARANCE	R 293 915.00
1.2	EARTHWORKS	R 2 345 895.00
1.3	STORMWATER MANAGEMENT	R 885 350.00
1.4	LAYERWORKS	R 869 009.00
1.5	KERBS & CHANNELS	R 303 315.00
1.6	ANCILLIARY	R 2 324 710.00
	Road Signs and Markings	
	Gabions	
	Concrete Work	
	Fences and Gates	
	Retaining Walls	
1.7	SUBSTATION BUILDING	R 2 566 500.00
	Concrete, Formwork & Reinforcement	
	Brickwork	
	Roof Coverings	
	Ironmongery	
	Plastering	
	Plumbing & Drainage	
	Painting	
	Small Power & Lighting	
1.8	MINOR STRUCTURES	R 1 846 300.00
	Solar MV Station Structure	
	BESS, Generator and PCS Structure	
1.9	PAVING	R 292 067.00
Sub-total A		**R 11 727 061.00**
2	**ELECTRICAL EQUIPMENT**	
2.1	GRID TIED PV SOLAR SYSTEM WITH ENERGY MANAGEMENT SYSTEM	R 27 615 000.00
	PV Solar Panels (JA Solar JAM 72S30 550W Modules)	
	String Inverters (Sungrow SG350HX 30A 16 MPPT)	
	Sungrow MVS3200-LV 11kV Grid Tie Inverter Station	
	Mounting Structures (Ground-Mount 2P 15 degree fixed tilt System)	
	Installation Cost	
	Consumables	
	DC Cables and General	
	AC Cables and General	
	MV Cable	
	Cable Management	
	Cable Trenching	
	Electrical Equipment and Protection	
	Lightning Protection and Earthing	
	Lightning Risk Assessment and COC	
	SCADA - Power Plant Controller (ELIM System or similar)	
	Inverter/Combiner mounting structure	

HARTENBOS WWTW - PV SOLAR & BESS: BUDGET ESTIMATE		
Item	**Description**	**Estimate**
	Meteocontrol (Weather Station)	
	Power Quality Analyser	
	Bulk Metering	
	Engineering and Project Management	
	Interfacing with Generator Control System	
	Transport to site	
	Grid Impact Study	
	On-site Commissioning	
	Interface with Energy Management System	
2.2	BATTERY ENERGY STORAGE SYSTEM WITH POWER CONVERSION SYSTEM	R 38 575 000.00
	Battery Energy Storage System (Sungrow 4586kWh) with SC1575UD PCS	
	Isolation Transformer (1.6MVA, 11/0.63kV)	
	Installation Cost	
	Consumables	
	DC Cables and General	
	AC Cables and General	
	MV Cable	
	Cable Management	
	Cable Trenching	
	Electrical Equipment and Protection	
	Lightning Protection and Earthing	
	Engineering and Project Management	
	Transport to site	
	Rigging of BESS	
	On-site Commissioning	
	Interface with Energy Management System	
2.3	STANDBY DIESEL GENERATORS	R 8 259 500.00
	800kVA, 400V, three-phase, standby diesel generator in canopy	
	Generator control panel - complete	
	Generator Step-up Transformer (1.6MVA, 11/0.4kV)	
	Neutral Earthing Resistor (11kV, 300A, 10sec)	
	Control cables between generator set and control panel	
	Third party inspection (Client FAT)	
	Crating and packaging	
	Packaging, Transport, Delivery and Off-loading on Site	
	Rigging, Installation and Testing	
	On-site Commissioning	
	Interface with Energy Management System	
2.4	MV (11kV) SWITCHGEAR	R 4 950 500.00
	Incomer (630A) - PUC Breaker (PUC Protection Relay)	
	Cable Feeders (630A)	
	PV Feeder (630A) (Complete with Cable VT and PUC Protection Relay)	
	Battery Feeder (630A) (Complete with Cable VT and PUC Protection Relay)	
	Generator Feeder (630A) (Complete with Cable VT and PUC Protection Relay)	
	Switchgear Operation & Maintenance Tools (Set)	
	Factory Acceptance Testing (3x Client representatives, 2 days)	
	Packaging, Transport, Delivery and Off-loading on Site	

HARTENBOS WWTW - PV SOLAR & BESS: BUDGET ESTIMATE		
Item	**Description**	**Estimate**
	Rigging, Installation and Testing	
	Battery Charger Unit (110VDC, 10Ah)	
	Detail Design - Secondary Plant Schemes	
	On-site Commissioning	
2.5	MV (11kV) POWER CABLES	R 945 500.00
	Supply and install 11/11kV, 70mm² x 3C, Cu, PILC, SWA, Cable (Table 18)	
	Supply and install 70mm² x 3C, Cu, PILC Indoor Cable Terminations	
	11kV Insulation Boot Kit	
	Supply and install 70mm² x 3C, Cu, 11/11kV, PILC, SWA Joint Kit	
	Pickable soil, 1000mm (deep) x 800mm (wide)	
	Backfilling and compaction, including bedding/blanket sand	
	SABS approved PVC Cable Warning Tape installed above cable in trench.	
	Cable markers	
2.6	SUBSTATION AUXILIARY SUPPLY (400VAC)	R 37 500.00
2.7	DOCUMENTATION & DRAWINGS	R 75 000.00
Sub-total B		**R 80 458 000.00**
3	**PROJECT COSTS**	
3.1	Preliminary & General (Estimated @14%)	R 12 905 908.54
3.2	Project & Estimating Contingencies (Estimated @5%)	R 5 254 548.48
3.3	1st Year Operations & Maintenance	R 385 000.00
Sub-total C		**R 18 545 457.02**
4	**CONSULTING ENGINEERING FEES**	
4.1	Professional Fees (as per ECSA Fee Scales)	R 6 823 715.00
4.2	Site Supervision	Included
Sub-total D		**R 6 823 715.00**
5	**SUB-CONSULTANTS**	
5.1	Environmental Impact Assessment (incl. Specialist Studies)	R 450 000.00
5.2	ECO, H&S, Topographical survey, geotechnical investigation and other project costs	R 250 000.00
Sub-total E		**R 700 000.00**
Total Project Cost (Excl. VAT)		**R 118 254 233.02**
VAT (@15%)		**R 17 738 134.95**
Total Project Cost (Incl. VAT)		**R 135 992 367.97**

Table 6-1: Budget Estimate for Hybrid Solution – Hartenbos WWTW

7 WAY FORWARD

The way forward is anticipated as presented below but may vary depending on various outcomes of the preliminary design approval process and particularly the EIA process:

7.1 Detail Design

- Based upon the acceptance of the preliminary design report, the project can continue to the detail design stage.
- Finalization of all of the above preliminary designs and data into detail designs.
- Detail specifications and drawings facilitated by the above detail designs.
- Monthly progress reports.
- Draft detail design report as output from the above processes, containing all of the above detail design parameters, detail specifications, detail drawings, project overview and final cost estimate and updated project program.
- Discussion with and approval of the above by client.
- Agree on implementation timeframes and project budget and cashflow with client.
- Final detail design report.

7.2 Procurement

- Compile tender document (inclusive of all construction specifications, designs, drawings and construction schedule) in line with agreed standards.
- Facilitate and manage tender process.
- Tender adjudication and report.
- Discuss tender report with client and agree on all outstanding issues.
- Obtain written instruction from client to proceed with appointment of relevant contractor.

7.3 Implementation

- Facilitate construction commencement by appointed contractor.
- Construction monitoring.
- Contract management during the construction stage, including but not limited to the following (refer ECSA guidelines):
    - Monthly progress reports
    - Budgetary (and cashflow) monitoring and reporting
    - Programming and progress monitoring and reporting
    - Quality control of all construction specifications, designs & drawings
    - Payment certificates
    - Chairing of site meetings
    - Minutes
    - Keeping of all required construction and legislative statistics
    - Labour statistics management and records keeping (if required)
- Manage Health and Safety (H&S / OHS) during construction.
- As built drawings and documentation.

7.4 Project Completion and Commissioning

- Completion of all activities.
- Commissioning to specifications.
- Completion and submission of as-built drawings (record drawings) and other record data required by the client.
- Project completion report.
- Compilation of Operations and Maintenance manuals.

8 CONCLUSION & RECOMMENDATIONS

8.1 Conclusions

The following can be concluded from the preliminary design report for the implementation of embedded renewable energy generation and storage options on the critical infrastructure at the Hartenbos WWTW:

1. The Hartenbos Wastewater Treatment Works provides an ideal scenario for the implementation of renewable energy and battery storage, due to the following considerations:

    a. Treatment works has a very constant base load.
    b. Critical application, requiring standby diesel generation.
    c. Space around the plant for the installation of renewable energy sources.
    d. Not within the residential areas.
    e. Already identified as ideal position for application of renewable energy generation.
    f. Proposed PV Solar & BESS installation area (5.82ha) available in close proximity to the water treatment works.
    g. Proposed PV Solar & BESS installation area belongs to the Mossel Bay Municipality and has already been disturbed, which will simplify the EIA process.
    h. Entire plant area is already fenced and secured, which limits the risk of theft and vandalism.
    i. All loads being supplied from local (existing) LV switchboards.
    j. Localised MV supply network, dedicated for the supply of the treatment works, which will require minimal amount of modification to accommodate “islanded” operation.
    k. Sufficient space within the plant boundaries for the positioning of battery storage containers, standby generators and additional MV switchgear that will be required as part of the renewable energy plant installation.

2. An inception meeting for the project was conducted on 08 June 2023. This was followed by a detailed site investigation with the client’s full team. A walkthrough and a discussion were held on all the existing infrastructure, the client’s needs and the anticipated upgrades to ensure all stakeholders were on the same level of understanding. Possible positions of new infrastructure were identified and confirmed between the parties. Current operating challenges were discussed. Conditions of existing infrastructure were discussed.
3. The process plant equipment is currently being supplied via four (4) 400 kVA, 11/0.4kV minisubs, feeding onto Main LV Boards (400V-MCCs), from which the distribution to the various pumps, aerators and other plant equipment is being done.
4. The bulk medium voltage connection (normal supply) to the plant is via an 11kV overhead line from the Main Intake (66/11kV) Substation, which feeds onto an RMU, located in close proximity to MS-B and MS-C.
5. An alternative (standby) bulk MV connection to the plant is via an 11kV overhead line from the Sonskynvallei (66/11kV) Substation, which feeds onto RMU-1, located near MS-RO Plant.
6. The individual metering data was obtained for each of the meters for the same metering period (01 January 2023 to 23 June 2023) and summated to determine the overall demand for the entire plant area.
7. It is important to note that for the metering period considered, five (5) x 45kVA floating aerator motors were not in services, as they were being refurbished. For this reason, their possible contribution to the overall plant load was taken into consideration by adding them as a constant load for the full duration of the period.
8. Furthermore, it should be noted that the Reverse Osmosis Plant was not in operation and therefore not included in the overall load estimations. Based on the information provided by the Mossel Bay

Municipality, this plant is only used in extreme drought conditions and should not be included as part of the calculations for the PV Solar & BESS system.

9. From the load profile analysis, it was determined that the average energy consumption for the plant is 925 kWh and the maximum demand recorded for any specific half-hour period was 1152kVA. These values were used in the calculations for the sizing of the PV solar plant, the inverters as well as the battery storage capacity.
10. The aim of the proposed solution was to design a hybrid system that will be grid-tied under normal operating conditions, providing battery backup as first line of support when the grid supply is interrupted.
11. Furthermore, standby diesel generators will also be incorporated into the system design to serve as a final level of support to the load when the batteries are depleted, and the grid supply (or PV solar generation) remains unavailable.
12. The best suited position for the PV solar plant has been identified on site, taking into account the slope and orientation of the land available. It is estimated that a total area of approximately 20000m^2 (2 ha) will be required for the installation of 3692 x 550Wp Solar Panels on Fixed Tilt Ground Mounted System.
13. An Environmental Impact Assessment (EIA) will be required. A Basic Assessment process will be applied for. This preliminary design report will enable the commencement of the EIA process and will be instrumental in the EIA application.
14. A project programme was presented and briefly discussed. A large number of unknowns are still present at this early stage of the project and the project programme may change accordingly. The preliminary design stage programme indicates completion of commissioning and handover on 30 June 2025.
15. A preliminary design stage cost estimate has been performed and will be refined during the detail design stage. The preliminary design stage cost estimate amounts to R135.99 mil (incl. P&G's, contingencies, escalation, professional fees & VAT).

8.2 Recommendations

1. In summary, it can be concluded that the proposed hybrid system will consist of the following:

   a. 1760 kVA grid-tied, free-field solar PV installation (requiring ± 20 000m^2 installation area).
   b. Installation of 3692 x 550Wp Mono-crystalline Solar Panels, which convert the solar radiation into direct current.
   c. Fixed tilt ground mounting structures, which supports the PV modules.
   d. 5x String inverters, which convert the DC from the solar field to AC.
   e. 1x MV Inverter Station (3.2MVA), which collects the AC output from each of the inverters and incorporates a step-up power transformer, which steps the inverter output voltage up to the 11kV network voltage. The inverter station also has integrated 11kV switchgear to connect to the MV network.
   f. 4512 kWh Battery Energy Storage System (consisting of 2x 2256kWh batteries in containers).
   g. 1x 1.757 MVA Power Conversion System (PCS), which converts the DC battery output to AC power.
   h. 1x 1.6 MVA Isolation transformer, which steps the PCS output up to 11kV.
   i. 2x 800 kVA Backup Diesel Generators (containerised).
   j. 1x 1.6 MVA Step-up transformer, which steps the generator output up to 11kV.
   k. 6x 11kV (25kA) AIS switchgear panels, complete with associated protection, metering and control elements, to be housed in a new substation building.
   l. 1x 11kV Neutral Earthing Resistor (NER), to be installed on the star-point of the generator step-up transformer's MV winding.
   m. DC cables (LV).

n. AC cables (LV & MV).
o. Energy Management System.
p. Communication Network.

2. Furthermore, it is recommended that the existing 11kV ring network be re-configured to allow for a single Point of Utility Connection (PUC).

9 ADDENDA

9.1 Addendum 1 – Proposed Site Development Plan

9.2 Addendum 2 – Proposed Single Line Diagram

9.3 Addendum 3 – Proposed Network Configuration Diagram

Rev.	Date	Description	Rev. by
A	21/08/2023	FOR INFORMATION	MP

ELEMENT Consulting Engineers
A FIFTH DIMENSION TO ENGINEERING

82 Victoria Street,
George, 6530

P O Box 9962,
George, 6529

Tel: +27 44 884 1138
Fax: +27 44 884 1185
E-Mail: info@eceng.co.za

Client/Employer

MOSSEL BAY MUNICIPALITY
Private Bag X29
MOSSEL BAY
6500

Tel : 044 606 5000

Project

HARTENBOS WWTW PV SOLAR & BESS

Plan Description

PROPOSED SITE DEVELOPMENT PLAN
OPTION 2

	Name	Signature
Designed	JF	
Drawn	MP	
Checked	HL	
Approved	JF	
Pr. No.		

Scale: 1:1000

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ORIGINAL SIZE A1

Contract No.: 2300431

Drawing No.: 2300431/C/002

Revision: A

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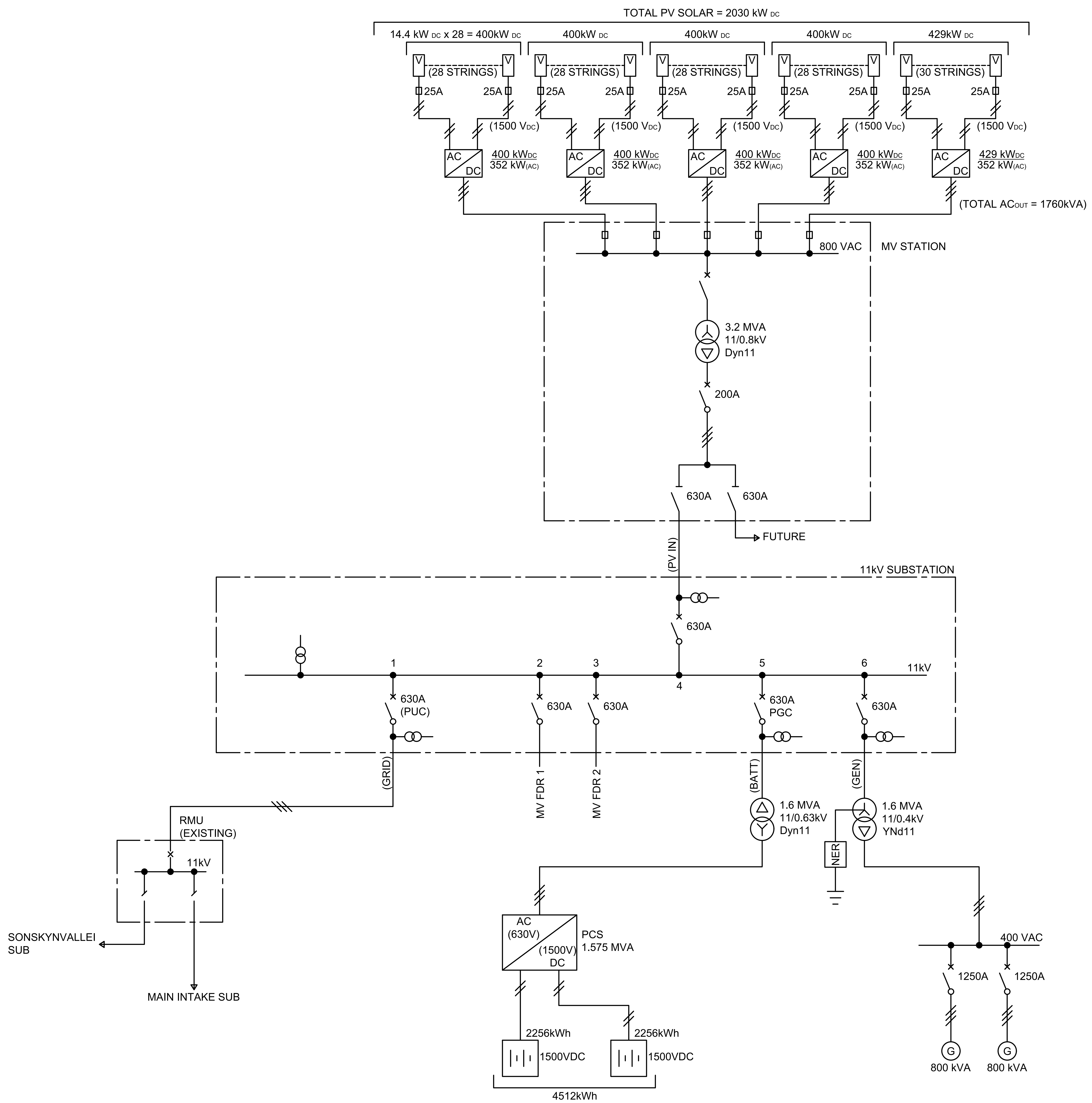

A	10/08/2023	FOR INFORMATION	TS
Rev.	Date	Description	Rev. by

ELEMENT Consulting Engineers
A FIFTH DIMENSION TO ENGINEERING

82 Victoria Street,
George, 6530

P O Box 9962,
George, 6529

Tel: +27 44 884 1138
Fax: +27 44 884 1185
E-Mail: info@eceng.co.za

Client/Employer

Mossel Bay MUNICIPALITY

Private Bag X29, MOSSEL BAY 6500
Tel : 044 606 5000

Project

HARTENBOS WWTW PV SOLAR & BESS

Plan Description

PROPOSED SINGLE LINE DIAGRAM

	Name	Signature
Designed	JF	
Drawn	TS	
Checked	JF	
Approved	JF	
Pr. No.		

Scale: AS SHOWN — 0 5 10 15 20 30 50mm — ORIGINAL SIZE A1

Contract No. 2300431

Drawing No. 2300431/E/001

Revision A

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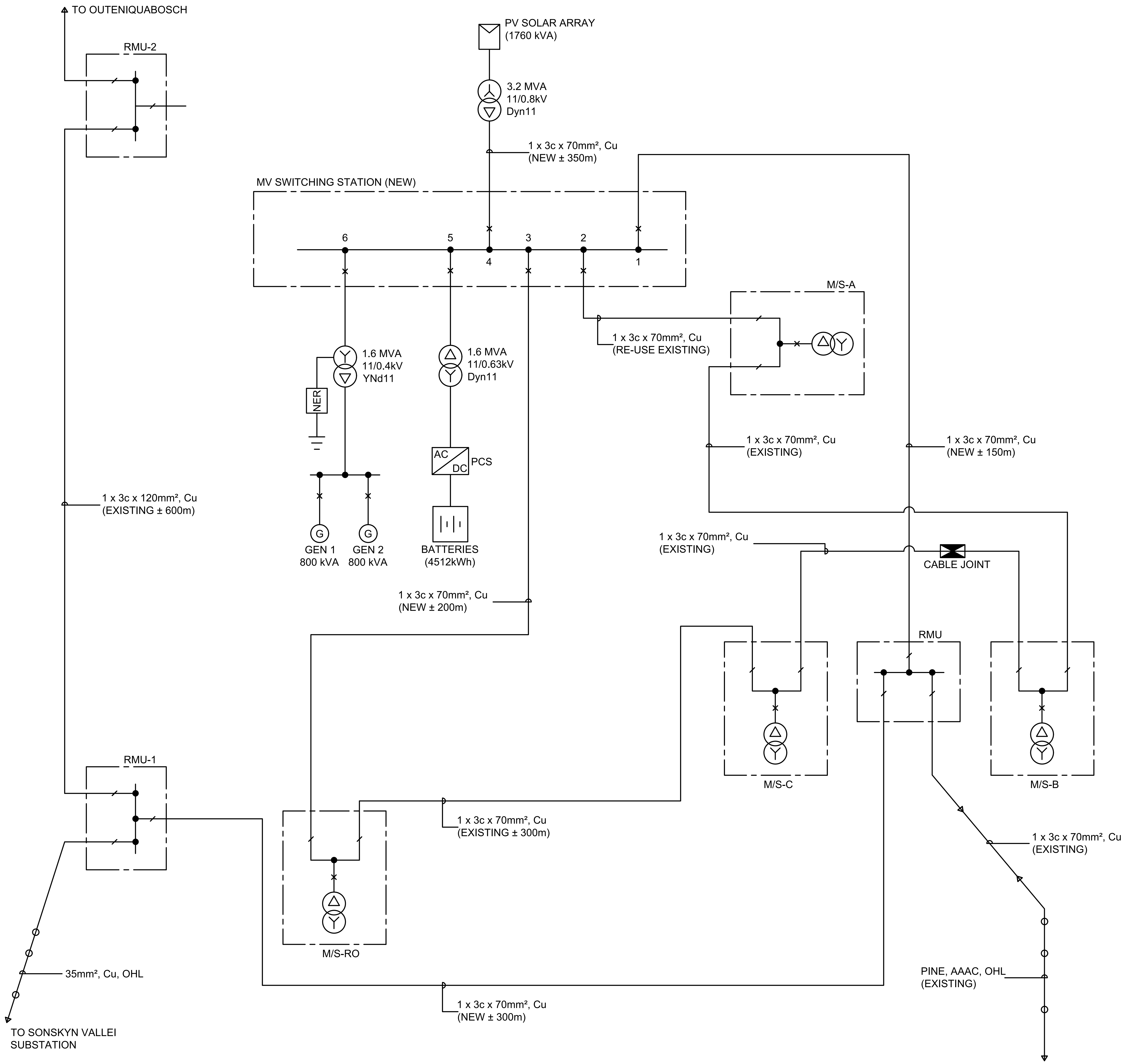

Rev.	Date	Description	Rev. by
A	10/08/2023	FOR INFORMATION	TS

ELEMENT Consulting Engineers
A FIFTH DIMENSION TO ENGINEERING

82 Victoria Street,
George, 6530

P O Box 9962,
George, 6529

Tel: +27 44 884 1138
Fax: +27 44 884 1185
E-Mail: info@eceng.co.za

Client/Employer

Mossel Bay
MUNICIPALITY

Private Bag X29, MOSSEL BAY 6500
Tel : 044 606 5000

Project

HARTENBOS WWTW PV SOLAR & BESS

Plan Description

PROPOSED NETWORK CONFIGURATION

	Name	Signature
Designed	JF	
Drawn	TS	
Checked	JF	
Approved	JF	
Pr. No.		

Scale: AS SHOWN
0 5 10 15 20 30 50mm
ORIGINAL SIZE A1

Contract No.: 2300431

Drawing No.: 2300431/E/002

Revision: A

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