Nauru Utilities Corporation

Load Flow and Fault Study

Nauru Utilities Corporation

3 September 2024

→ **The Power of Commitment**

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The Power of Commitment

Executive summary

Nauru, a Pacific Island country, has approximately 13,300 residents. It predominantly sources its energy through diesel power generators. About 5% of its current energy demand is sourced from renewable energy of which all are solar Photovoltaic (PV) installations. The Government of Nauru has a target to increase the annual energy renewable penetration within Nauru to 50%. At the request of the Government of Nauru, the Asian Development Bank (ADB) provided support for the development of a Solar Power Expansion Plan, and using the recommendations undertake a feasibility study for a solar facility for Nauru.

This revised study was initiated for the following reasons:

(1) Nauru Utilities Corporation (NUC) has decided not to relocate the existing gensets.

(2) Recently, NUC has provided an updated SLD.

(3) Furthermore, the contractor (CHEC) has advised that their BESS and solar have different fault current capabilities.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.3 and the assumptions and qualifications contained throughout the Report. This report summarises the results and findings of a steady state study that GHD has carried out on the NUC Network. The study period considers the load forecast maximum of 7.5 MW, shoulder load of 5.5 MW and minimum of 2 MW. In this study, simulations were carried out using DIgSILENT PowerFactory to analyse the steady state network response. The key outcomes of the study are summarised below.

Steady-state load flow study findings:

Normal Conditions

There were no overvoltages observed for the operation scenarios considered.

At diesel only operation at maximum load, undervoltage was observed at RPC3RPC2Ronphos 11kV bus, which was at 9.89 kV (0.899 p.u.). In the same scenario, three main transformers T1, T2 and T3 were all overloaded at ~114%. These issues however were due to the load growth modelled and not associated with the connection of the solar or BESS.

Contingency Events

During the Express Feeder network configuration (i.e. Field Feeder open or faulted) and maximum load when running in diesel off mode (Scenario 1), the Express Feeder conductor is overloaded (108.5%) based on the Krypton conductor rating of 410 A.

Conversely, during the Field Feeder network configuration (i.e., Express feeder open or faulted) and maximum load when running in diesel off mode (scenario 1), the Field Feeder conductor is marginally overloaded (101.4%).

It is therefore recommended that a protection or control system is installed to prevent this overload at diesel-off maximum load operation, and dispatch additional gensets if required.

Short-circuit fault study findings:

Fault studies were conducted to determine the minimum and maximum fault currents from the six operational scenarios. Among the six scenarios, maximum fault currents were observed for the mixed operation of renewables and diesel (Scenario 5), while minimum fault currents were observed for the BESS only operation (Scenario 6).

Study recommendations and future works:

The primary objective of this steady state modelling is to ensure the equipment will not have thermal overloading, voltage regulation issues or exceed equipment fault ratings at different load and generation dispatch scenarios. GHD has developed the DIgSILENT model based on information made available by NUC however the effective As Built information had a number of limitations and assumptions had to be made. To further improve the model, a process of validation of the models could be undertaken by NUC including:

- Generator governor and real power capability curves.
- Transformer tap settings.
- Network configuration verification
- Detailed load measurements per transformation (rather than scaling based on nameplate rating)

Future works include:

- Verification by CHEC to confirm fault current contribution of solar and BESS inverters acts as a fixed current source (i.e. irrespective of impedance of fault)
- Analysis of unbalanced/earth faults and ability to detect and clear (including earth return path analysis).
- Development of detailed protection and control design by CHEC

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1. Introduction

This study is based on the findings from the Solar Power Expansion Plan, and a subsequent submission made to the Government of Nauru Cabinet by NUC in September 2018. The impact of renewable energy integration to the grid and installation of battery capacity of 2.5 MWh / 5 MW initially is studied in this report. Based on this, and discussions with NUC and ADB, GHD commenced this study for the development of 6 MWac solar coupled with 5 MW / 2.5 MWh of battery storage located at the Canstruct site.

The aim of the Nauru Solar Power Development Project is to increase the supply of cleaner electricity for Nauru. The country has a target of achieving 50% of its energy demand to be sourced from renewable energy, all of which is expected to be from solar power installations, by 2020, in accordance with the Republic of Nauru Energy Road Map 2014-2020. The investigation of the feasibility of expanding the solar power installation and battery energy storage system in Nauru considered multiple criteria, such as technical, financial and economic, environmental and social aspects, and associated project risks and constraints. The multi-criteria analysis, as outlined in the Solar Power Expansion Plan, led to identifying options, and determining the preferred option to achieve 50% renewable energy targets, with the date of achieving this target moved to 2025.

1.1 Purpose of this report

Power system studies are required to be carried out to assess system network performance to facilitate integration of renewables into NUC network. In this report, GHD has carried out steady state studies of NUC network for six scenarios to analyse network performance.

1.2 Scope

The scope of this report includes steady state studies to assess the performance of the NUC network with and without the integration of solar PV and BESS using DIgSILENT PowerFactory. This study will allow to identify any requirement of upgrade of existing asset and assess the integration of the PV/BESS to the NUC network.

1.3 Limitations

This study does not confirm the stability of the scenarios discussed.

No analysis or recommendations in this report limit the Solar and BESS Contractor's (CHEC) detailed design responsibilities including with respect to protection, SCADA and control and earthing design.

This report: has been prepared by GHD for Nauru Utilities Corporation and may only be used and relied on by Nauru Utilities Corporation for the purpose agreed between GHD and Nauru Utilities Corporation as set out in Section 1.1 this report.

GHD otherwise disclaims responsibility to any person other than Nauru Utilities Corporation arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

1.4 Inputs, Assumptions and Reliance

GHD has prepared the "NauruADBSolarCMexprsfr2022-202403.pfd" ("Model") which has informed this technical note for, and for the benefit and sole use of, NUC to support the connection of the solar PV and BESS and must not be used for any other purpose or by any other person.

The Model is a representation only and does not reflect reality in every aspect. The Model contains simplified assumptions to derive a modelled outcome. The actual variables will inevitably be different to those used to prepare the Model. Accordingly, the outputs of the Model cannot be relied upon to represent actual conditions without due consideration of the inherent and expected inaccuracies. Such considerations are beyond GHD's scope.

The information, data and assumptions ("Inputs") used as inputs into the Model are from publicly available sources or provided by or on behalf of the NUC (including possibly through stakeholder engagements). GHD has not independently verified or checked Inputs beyond its agreed scope of work. GHD's scope of work does not include review or update of the Model as further Inputs becomes available.

The Model is limited by the mathematical rules and assumptions that are set out in the Report or included in the Model and by the software environment in which the Model is developed. The Model is a customised model and not intended to be amended in any form or extracted to other software for amending. Any change made to the Model, other than by GHD, is undertaken on the express understanding that GHD is not responsible, and has no liability, for the changed Model including any outputs.

GHD has not undertaken an independent validation or verification of the previous work or As Built data provided by NUC or the Contractor (CHEC).

Assumptions are as detailed throughout this report including all load data, SLD and as built information as provided by NUC and the Contractor. Specific assumptions include:

- Network configurations (including normally open points) and equipment ratings are as per provided SLDs
- Load scaling is based on nameplate rating of distribution transformers
- Fault current contribution of solar and BESS inverters is modelled as a fixed current source (i.e. irrespective of impedance of fault for balanced and unbalanced faults)
- Duration of PV and BESS inverter fault current contribution is long enough to operate the considered protection schemes (Sensitivity of per unit fault current magnitude analysed in Section 4.2.2)

1.5 Acronyms and Standards

The following terms and abbreviations are applicable to this document:

Table 1 Acronyms

Acronym	Description
AC	Alternating Current
DC	Direct Current
HV (or MV)	High Voltage as defined by Australian Standards (> 1000 Vac or > 1500 Vdc)
IEC	International Electrotechnical Commission
LV	Low Voltage
MVA	Mega Volt Ampere
MVAR	Mega Volt Ampere Reactive
MW	Mega Watt
O&M	Operation and Maintenance
O/H	Overhead
PF	Power factor

Acronym	Description
PS	Power Station
RMU	Ring Main Unit
SLD	Single Line Diagram
SPD	Surge Protection Device
U/G	Underground

A list of standards applicable to this report is listed below.

Table 2 Standards

Standard	
Complete Method	Superposition method of short-circuit analysis
IEC 60909	Short-Circuit currents in three phase AC systems

Table 3 Symbols

Symbols	Description
Ip	Peak short circuit current, maximum possible instantaneous short-circuit current
Ib	Symmetrical short circuit breaking current, RMS value of an integral cycle of the symmetrical ac component of the short circuit current at the instant of contact separation of the first pole of a switching device
Ik	Steady state short circuit current, RMS value of short circuit current which remains after the decay of the transient component
Ith	Thermal equivalent short circuit current, RMS value of a current having the same thermal effect and the same duration as the actual short circuit current, which may contain a dc component and may subside in time

2. Methodology

The load flow and fault study methodologies are described in this section.

1. Load Flow Calculation

    a. Newton-Raphson algorithm was used.

    b. The loading current capacity of equipment used in this report are from the vendor data.

    c. The following standards are used to assess the load flow study results:

        i. Except as a consequence of a non-credible contingency event, the minimum steady-state voltage on the system operating at voltages of 11 kV must be 90% of nominal voltage and the maximum steady state voltage must be 110% of nominal voltage.

        ii. For those parts of the distribution system operating below voltages of 11 kV, the steady state voltage must be within: ± 6% of the nominal voltage during normal operating state.

    d. No transformer tap setting optimization and voltage control mechanism have been considered.

2. Short-Circuit Calculation

    a. The IEC 60909 method was used to calculate maximum three-phase fault currents at all the buses in the network and fault is implemented to all the buses.

    b. The complete method was used to calculate the maximum single phase to ground currents, the minimum three-phase fault currents and minimum single phase to ground currents at all the buses in the network and fault is implemented to all the buses.

    c. For IEC 60909 method, a c factor of 1 is used.

    d. Fault current contribution from equipment is as per Section 3.3.2.

    e. The main objective of this fault study is to determine the following:

        i. the maximum fault levels at bus locations within the NUC network to determine the required fault rating of circuit breakers/switchgears; and

        ii. the minimum fault levels at bus locations within the NUC network to investigate if overcurrent protection will operate or not.

3. Model Development & Scenarios

An electrical model of the Nauru electrical network has been built in PowerFactory to carry out the steady state analysis presented in this report. This section describes the development of the steady state base model for the network and the input data used for the model.

3.1 Model Updates from the Previous Study

The previous issued report for this project was "Revised System Study - TA-9242 REG: Pacific Renewable Energy Investment Facility- NAU-01 Project Preparation-Consultancy (49450-001)". Updates have been made to the GHD's developed DIgSILENT PowerFactory Model of the Nauru grid. The model was developed as a part of feasibility study done by GHD to assess and plan for the agreed renewable penetration through the design of a PV solar and a BESS system to complement the existing diesel power station and distributed solar PV. Changes to the model were made in accordance with the updated single line diagram (refer to Appendix A and Appendix D) and feedback provided by AS, who confirmed the planned changes in design to the grid. This principally involved the following:

- The generators connected to the 3.3 kV bus are updated as per on site setup and recently provided SLD- "ADB SOLAR INTERFACE TO 11KV SLD-Model – UPDATED 20-10-2022" (see Appendix D).
- Fuel Tank Farm Load increased to 200 kW
- ODIN AIWO load connected to Ringmain East- Civic Bus
- Transformer impedances were updated (see Tables 9 and 10: Transformer and Generator Transformer Particulars)
- A moderate load scenario was added.
- The diesel generators were recommended to be loaded above 60% for the Scenario 3 and Scenario 5 (Refer to section 3.3.1).
- An additional case of 2.0 p.u. BESS fault contribution was considered upon CHEC's confirmation that they will comply with the 2.0 p.u. requirement.

3.2 Steady State Modelling Approach

In considering grid stability implications and effect of high penetration renewables in a microgrid, the primary consideration is to ensure the output (and intermittency) of the new installation (centralised PV and BESS) does not result in any flow-on impacts to operation of the existing generation equipment or loads. This can be achieved through equipment loading studies and steady-state voltage regulation studies, among others.

3.3 List of Scenarios

A list of scenarios considered for load flow studies and fault studies is provided below.

3.3.1 Load Flow Study Scenarios

Several scenarios are investigated in the load flow study. The objectives of this study are as follows:

1) To assess the effect of network voltage variations
2) To assess the loading of the cables and verify the selected cable sizes
3) To assess the thermal overloading of any of the assets in the network

A steady state modelling is done for the following scenarios to cover all credible operating modes and scenarios:

- **Scenario 1:** Annual maximum load of 7.5 MW @ 0.93 p.f. 100% supply from BESS and PV (in diesel off mode);
- **Scenario 2:** Annual minimum load of 2 MW @ 0.93 p.f. 100% supply from BESS and PV (in diesel off mode);

- **Scenario 3:** Annual maximum load of 7.5 MW @ 0.93 p.f. 100% supply from diesel power station (in existing location);
- **Scenario 4:** Annual minimum load of 2 MW @ 0.93 p.f. 100% supply from diesel power station (in existing location)
- **Scenario 5:** Moderate load of 5.5 MW @ 0.93 p.f., with 52% of supply coming from PV and 48% from diesel generation**;** and
- **Scenario 6:** Annual minimum load of 2 MW @ 0.93 p.f. 100% supply from BESS (PV off and diesel off mode).

As per “Solar Power Development Project: Feasibility Study”, the solar PV plant will have an AC capacity of 6.0 MWac and 6.9 MWdc (at STC) and the battery energy storage system (BESS) capacity of 5 MW and 2.5 MWh. The BESS will be composed of two separate systems of 2.5 MW, 1.25 MWh capacity. The drawing “DQ01-001 Electrical Single Line Diagram2022.09.23” shows the electrical arrangement of the PV and BESS.

Table 4 to Table 8 show the generator loading and voltages for each study scenario.

Table 4 Scenario 1 (maximum load) Diesel off

Generator	Busbar	Bus type	Active power (MW)	Reactive power (MVAr)	Apparent Power (MVA)	Rating (MVA)	Voltage (p.u.)	Power Factor	Loading (%)	Spinning reserve (MW)
MANG2	G2-1	PV	Offline							
Cummins G5	G5	PQ	Offline							
Cummins G10	G10	PQ	Offline							
Cummins G2A	G2	PQ	Offline							
Cummins G7	G7-8	PQ	Offline							
G4 Ruston	G4	PQ	Offline							
ADB Solar	ADBSolar	PQ	6	0	6	6	1.063	1	100	0
MFAT Solar	MFATSolar	PQ	0.9	0	0.9	0.9	1.063	1	100	0
UAE Solar	UAESolar	PQ	0.3	0	0.3	0.3	1.032	1	100	0
BESS	ADB Solar	PV	0.63	3.7	3.8	5	1.063	0.166	76	2.69

Table 5 Scenario 2 (minimum load) Generator loading

Generator	Busbar	Bus type	Active power (MW)	Reactive power (MVAr)	Apparent Power (MVA)	Rating (MVA)	Voltage (p.u.)	Power Factor	Loading (%)	Spinning reserve (MW)
MANG2	G2-1	PV	Offline							
Cummins G5	G5	PQ	Offline							
Cummins G10	G10	PQ	Offline							
Cummins G2A	G2	PQ	Offline							
Cummins G7	G7-8	PQ	Offline							
G4 Ruston	G4	PQ	Offline							
ADB Solar	ADBSolar	PQ	1.35	0	1.35	6	1.015	1	22.5	4.650
MFAT Solar	MFATSolar	PQ	0.27	0	0.27	0.9	1.015	1	30	0.630
UAE Solar	UAESolar	PQ	0.3	0	0.3	0.3	1.052	1	100	0
BESS	ADB Solar	PV	0.29	0.92	1.00	5	1.015	0.29	20.0	4.62

Table 6 Scenario 3 (maximum load) Generator loading

Generator	Busbar	Bus type	Active power (MW)	Reactive power (MVAr)	Apparent Power (MVA)	Rating (MVA)	Voltage (p.u.)	Power Factor	Loading (%)	Spinning reserve (MW)
MANG2	G2-1	PV	2.8297	1.604	3.253	3.562	1.000	0.870	91.3	0.350
G4 Ruston	G4	PQ	1.739	0.61	1.843	2.2	0.965	0.944	83.8	0.375
Cummins G2A	G2	PQ	1.12	0.61	1.275	1.4	1.031	0.878	91.1	0.140
Cummins G5	G5	PQ	1.12	0.61	1.275	1.4	1.031	0.878	91.1	0.140
Cummins G7	G7-8	PQ	1.12	0.61	1.275	1.4	1.044	0.878	91.1	0.140
Cummins G10	G10	PQ	Offline							
ADB Solar	ADBSolar	PQ	Offline							
MFAT Solar	MFATSolar	PQ	Offline							
UAE Solar	UAESolar	PQ	Offline							
BESS	ADB Solar	PV	Offline							

Table 7 Scenario 4 (minimum load) Generator loading

Generator	Busbar	Bus type	Active power (MW)	Reactive power (MVAr)	Apparent Power (MVA)	Rating (MVA)	Voltage (p.u.)	Power Factor	Loading (%)	Spinning reserve (MW)
MANG2	G2-1	PV	1.5394	0.837	1.752	3.562	1	0.879	49.2	1.923
Cummins G2A	G2	PQ	0.685	0.155	0.702	1.4	1.028	0.975	50.2	0.706
G4 Ruston	G4	PQ	Offline							
Cummins G5	G5	PQ	Offline							
Cummins G7	G7-8	PQ	Offline							
Cummins G10	G10	PQ	Offline							
ADB Solar	ADBSolar	PQ	Offline							
MFAT Solar	MFATSolar	PQ	Offline							
UAE Solar	UAESolar	PQ	Offline							
BESS	ADB Solar	PV	Offline							

Table 8 Scenario 5 (moderate load) Generator loading

Generator	Busbar	Bus type	Active power (MW)	Reactive power (MVAr)	Apparent Power (MVA)	Rating (MVA)	Voltage (p.u.)	Power Factor	Loading (%)	Spinning reserve (MW)
MANG2	G2-1	PV	1.8523	1.389	2.315	3.562	1.099	0.8	65	1.428
Cummins G5	G5	PQ	0.9	0	0.9	1.4	1.061	1	64.3	0.5
Cummins G2A	G2	PQ	Offline							
G4 Ruston	G4	PQ	Offline							
Cummins G7	G7-8	PQ	Offline							
Cummins G10	G10	PQ	Offline							
ADB Solar	ADBSolar	PQ	2.1	0	2.1	6	1.011	1	35	3.9
MFAT Solar	MFATSolar	PQ	0.7	0	0.7	0.9	1.011	1	78	0.2
UAE Solar	UAESolar	PQ	0.2	0	0.2	0.3	1.041	1	67	0.1
BESS	ADB Solar	PV	Offline							

Table 9 Scenario 6 (minimum load) Generator loading

Generator	Busbar	Bus type	Active power (MW)	Reactive power (MVAr)	Apparent Power (MVA)	Rating (MVA)	Voltage (p.u.)	Power Factor	Loading (%)	Spinning reserve (MW)
MANG2	G2-1	PV	Offline							
Cummins G5	G5	PQ	Offline							
Cummins G2A	G2	PQ	Offline							
G4 Ruston	G4	PQ	Offline							
Cummins G7	G7-8	PQ	Offline							
Cummins G10	G10	PQ	Offline							
ADB Solar	ADBSolar	PQ	Offline							
MFAT Solar	MFATSolar	PQ	Offline							
UAE Solar	UAESolar	PQ	Offline							
BESS	ADB Solar	PV	2.21	0.999	2.75	5	1.015	0.805	36.4	2.01

3.3.2 Fault Study Scenarios

The same scenarios used in the load flow studies are considered for the fault studies.

3.4 Summary of System Loads

The load is modelled according to the same method as per previous studies – i.e. total system demand figures distributed proportionally based on distribution transformer nameplate kVA with LV loads modelled as lumped loads. A summary of the system loads is presented below:

Table 10 Summary of system loads

Load	Feeder	Scenario 1 & 3 (kW)	Scenario 2, 4 & 6 (kW)	Scenario 5 (kW)	Power factor (pf)
Command Ridge	Field	94	25	69	0.93
Domestic sub	Field	47	13	34	0.93
Fuel tank farm	Field	94	25	69	0.93
Prison	Field	47	13	34	0.93
Rehab workshop	Field	469	125	344	0.93
RONPHOS crusher	Field	919	245	674	0.93
RPC1	Field	563	150	413	0.93
RPC2	Field	375	100	275	0.93
RPC3	Field	188	50	138	0.93
RONPHOS drier	3.3 kV	459	122	337	0.93
Airport	East	134	36	98	0.93
Civic	East	67	18	49	0.93
Fresh Centre	East	157	42	115	0.93
Gon	East	349	93	256	0.93
Pago	East	67	18	49	0.93
Anabar	North	191	51	140	0.93
Arijejen	North	620	165	455	0.93
Ijuw	North	250	67	184	0.93
Ronave	North	258	69	189	0.93
Waboe	North	398	106	292	0.93

The Bay	North	129	34	95	0.93
Junct1	South	419	112	308	0.93
Junct2	South	341	91	250	0.93
Terrace	South	427	114	313	0.93
Additional loads					
Government office	East	144	38	106	0.93
Menen Hotel	North	145	39	106	0.93
Anibar Workers Camp	North	63	17	46	0.93
Nibok Camp	North	43	11	32	0.93
Ewa Camp	North	43	11	32	0.93
Total demand		7500	2000	5502	

Source: Initial data from MFAT, scaled by GHD. For Scenario 5, the individual loads were calculated by scaling the loads from Scenario 1&3 by a factor = (moderate demand of 5.5 MW)/(total maximum demand of 7.5 MW).

3.5 Model Inputs

3.5.1 Network Configuration

- The network configuration has been modelled as per Appendix D.
- Transformer T4 has been modelled out of service for all scenarios.
- Field Feeder (FF) and Express Feeder (EF) are modelled closed for the base case scenarios. With this network configuration, FF and EF effectively operate as parallel interconnectors as far as the supply to the North, South and East feeders are concerned. This is envisioned to be the default network configuration as it is more efficient and provides partial redundancy.
- The nominal MV network configuration and the location of Normally Open Points (NOP) between the South, North, East and Field feeders are shown as green circles in the SLD in Appendix D. NOPs by the Fresh Centre, the New Prison and the Menen Hotel are modelled by open circuit breakers. The existing line between the Gon and Gonway busbars is also disconnected and is a NOP in the SLD.

3.5.2 Transformer and conductor

Transformers:

- PV1&2 0.48/11kV transformer – 6% at 2MVA
- PV3 0.48/11kV transformer – 6% at 2.5MVA
- BESS 0.4/11kV transformer – 6% at 2.75MVA

Table 11 Network Transformer Particulars

PARTICULARS	RM SOUTH	RM EAST	RM NORTH
Rated KVA	2500	2500	2500
Phases	3	3	3
Frequency	50	50	50
Volts, HV	11000	11000	11000
Volts, no load LV	3300	3300	3300
Amperes, HV	131.2	131.2	131.2
Amperes, LV	437.4	437.4	437.4
Vector Symbol	YNd 11	Dyn 11	YNd 11
Impedance (Rated KVA) @75%	5.97	5.97	5.96

Table 12 Generator Transformer Particulars

PARTICULARS	GEN 2A & G2B	GEN 3	GEN 4 Rus	GEN 5	G7B	MAN
Rated KVA	1500	1500	33500	1500	1500	4000
Phases	3	3	3	3	3	3
Frequency	50	50	50	50	50	50
Volts, HV	3300	3300	11000	3300	3300	11000
Volts, no load LV	415	433	3300	415	433	3300
Amperes, HV	262	262	612.3	262	262	209.95
Amperes, LV	2087	2000	183.7	2087	2000	699.82
Vector Symbol	YNd 11	Dyn 11	Dyn11	YNd 11	Dyn 11	Dyn 11
Impedance (Rated KVA) @75%	5.79%	6.04%	4.71%	5.72%	5.99%	7.25%

Table 13 Conductor Particulars

PARTICULARS	AC Resistance
Krypton AAAC	0.227 Ohm/km
ABC 150 Al	0.261 Ohm/km
185CuUG	0.099 Ohm/km

3.5.3 Fault contributions

Fault current contribution impacts steady-state fault levels. As such, the fault current contribution of synchronous generation and inverter-coupled sources are considered as follows.

Synchronous Generation (alternator-based)

Sources as follows:

- Cummins Diesel Sync gen units – 692% of rated output, 6.92 pu
- MAN Diesel Sync unit - 703% of rated output, 7.03 pu
- Ruston Diesel Sync gen units – 692% of rated output, 6.92 pu
- Fault current contribution of the diesel genset's alternator is modelled with a 15% sub-transient impedance. Specific AVR settings are not considered.

Inverter-Coupled Source

Following the initial power system modelling studies/memo (i.e. pre-EPC contract award), the Contractor advised that their proposed equipment did not comply with the minimum required fault current contribution requirements of the Contract (i.e., 200% of rated output or 2.0 p.u.) and was only capable of the following:

- BESS units – 150%[1] of rated output (i.e. 1.5 p.u.)
- PV units – 150%[1] of rated output (i.e. 1.5 p.u.)

The above values were therefore used for base modelling. However, due to subsequent clarification from the Contractor that the inverters were only capable of supplying this for a short duration for fault current contribution (i.e. <1ms), the following reduced fault contribution cases were also analysed to assess minimum fault current through the solar interconnector:

- The PV and the BESS fault current contributions are set to 1.0 p.u. and 1.3 p.u., respectively, in section 4.2.2 to determine the fault currents that may be seen based on different potential fault current contribution capabilities of the inverters.
- A BESS fault contribution of 1.04 p.u. was considered per the contractor's response on equipment capability (Appendix E).
- Also, a fault contribution of 1.0 p.u. for both PV and BESS is also considered in a study in the above-mentioned section of the report.

More recently, the BESS supplier confirmed that they will be designing the BESS to supply 2.0 p.u. fault current contribution. Hence, a BESS fault contribution of 2.0 p.u. was considered in addition.

4. Study Results

The load flow and fault study results are shown in the following sections.

The following colour scheme is used in the result tables to represent voltage, thermal loading, and fault currents that require attention or might require future attention.

red	Issues that require immediate attention, e.g., if the bus voltage is not within ±10% of rated voltage, if the equipment loading exceeds 100% of its thermal capacity, and if the fault current level exceeds the equipment's fault rating.
yellow	Issues that are marginally OK and might need future attention, e.g., bus voltage is not within ±5% of rated voltage, if the equipment loading exceeds 90% of its thermal capacity, and if the fault current level is above 90% of the corresponding network-allowed maximum fault rating.

[1] As per RFI - NUC_06122022(Contractor response2022.12.16) provided in Appendices.

Table 14 to Table 27 provide the load flow results of the different operating scenarios. The tables give key information about the solar farm such as conductor loadings and the voltage levels within the solar farm.

4.1.1 Scenario 1

In **Scenario 1**: Annual maximum load of 7.5 MW @ 0.93 p.f. 100% supply from BESS (in grid forming mode) and PV,

- No voltage and thermal loading issues have been identified.
- The highest voltages in the network are at ADBSolar and MFATSolar (1.063 p.u.). Since the ADBSolar and MFATSolar bus voltages are 11 kV i.e. >6 kV this is acceptable as per target criteria.
- The lowest voltages in the network are at Ijew (1.017 p.u.), Menen_N1 (1.016 p.u.), and TheBay (1.016 p.u.).
- Marginally loaded transformers are the 2-winding PV transformers at ADBSolar at 94.1% loading.

Table 14 Scenario 1 load flow results

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
11kVEast	11.0	11.4	1.036
11kVField	11.0	11.4	1.036
11kVNorth	11.0	11.4	1.036
11kVSolar	11.0	11.4	1.036
11kVSouth	11.0	11.4	1.036
ADBSolar	11.0	11.7	1.063
Airport	11.0	11.4	1.034
Anabar	11.0	11.2	1.018
Arijejen	11.0	11.4	1.033
Civic	11.0	11.4	1.034
CommandRidge	11.0	11.4	1.039
DomSub	11.0	11.4	1.039
EUSolar	11.0	11.6	1.053
FreshCentre	11.0	11.4	1.033
FreshCentre_S1	11.0	11.3	1.030
FuelTankFarm	11.0	11.4	1.039
G10	0.4	0.0	0.000
G2	0.4	0.0	0.000
G2-1	11.0	0.0	0.000
G3	0.4	0.0	0.000
G3-1	11.0	0.0	0.000
G4	11.0	0.0	0.000
G5	0.4	0.0	0.000
G6	0.4	0.0	0.000
G7-8	0.4	0.0	0.000
Gon	11.0	11.4	1.034
Gonway	11.0	11.4	1.033
Ijew	11.0	11.2	1.017
Junct1	11.0	11.4	1.033
Junct2	11.0	11.4	1.032
Junct5	11.0	11.3	1.031
MFATSolar	11.0	11.7	1.063
Menen_E1	11.0	11.4	1.033
Menen_E1(1)	11.0	11.6	1.053
Menen_N1	11.0	11.2	1.016
Menen_S2	11.0	11.3	1.028
PS3.3kV-A	3.3	3.4	1.034
PS3.3kV-B	3.3	3.4	1.034
Pago	11.0	11.4	1.034
RPC1	11.0	11.7	1.061
RPC3RPC2Ronphos	11.0	11.6	1.051
RehabWorkshops	11.0	11.6	1.053

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
Ronave	11.0	11.2	1.020
Terrace	11.0	11.3	1.028
TheBay	11.0	11.2	1.016
UAESolar	11.0	11.4	1.032
Waboe	11.0	11.3	1.027

Table 15 Scenario 1 thermal overloading results

Name	HV-Side	LV-Side	HV-Side V p.u.	LV-Side Vn p.u.	Loading (%)
2-Winding Transformer	MFATSolar	Terminal	1.063	1.063	84.7
2-Winding Transformer - UAESolar	UAESolar	Terminal(6)	1.032	1.071	23.2
BESS1 2-Winding Transformer	ADBSolar	BESS1 Terminal	1.063	1.100	64.6
BESS2 2-Winding Transformer	ADBSolar	BESS2 Terminal	1.063	1.100	61.0
PV1 2-Winding Transformer	ADBSolar	PV1 Terminal	1.063	1.274	94.1
PV2 2-Winding Transformer	ADBSolar	PV2 Terminal	1.063	1.274	94.1
PV3 2-Winding Transformer	ADBSolar	PV3 Terminal	1.063	1.275	75.3
T1	11kVEast	PS3.3kV-A	1.036	1.034	6.4
T2	11kVSouth	PS3.3kV-A	1.036	1.034	6.4
T3	11kVNorth	PS3.3kV-B	1.036	1.034	6.4
T4	- 11kVField	PS3.3kV-B	1.034	1.034	0.0

Contingencies at FF and EF were simulated for the maximum demand scenario (diesel off). When the FF tie is modelled open for “diesel off” operating scenarios, the PV/BESS supply power through the solar interconnector to the old power station and all the way back to the FF loads. This configuration results in higher losses, wider voltage regulation, lower fault levels and overload constraints. It is believed to be used operationally only in a contingency event, i.e., when the feeder is partially faulted. Below sections show the results of the contingency simulations.

4.1.1.1 Contingency at Field Feeder/Solar Interconnector

In this section, voltage regulation and thermal constraints are assessed for a contingency at Field Feeder/Solar Interconnector for scenario 1. Following are the results for field feeder out of service:

- The lowest voltages in the network can be found at RPC3RPC2Ronphos (0.929 p.u.), EUSolar (0.929 p.u.), and RPC1 (0.937 p.u.).
- Undervoltages are observed for Anabar, EUSolar, Ijew, Menen_E1(1), Menen_N1, RPC1, RPC3RPC2Ronphos, RehabWorkshops, and TheBay.
- Line(32) - Express Feeder is overloaded at 107.9%

Table 16 Load flow results at field feeder out of service- scenario 1

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
11kVEast	11.0	10.6	0.968
11kVField	11.0	10.6	0.968
11kVNorth	11.0	10.6	0.968
11kVSolar	11.0	10.6	0.968
11kVSouth	11.0	10.6	0.968
ADBSolar	11.0	11.6	1.056
Airport	11.0	10.6	0.966
Anabar	11.0	10.4	0.949
Arijejen	11.0	10.6	0.965
Civic	11.0	10.6	0.966
CommandRidge	11.0	10.6	0.963
DomSub	11.0	10.6	0.963
EUSolar	11.0	10.2	0.929
FreshCentre	11.0	10.6	0.965
FreshCentre_S1	11.0	10.6	0.962
FuelTankFarm	11.0	10.6	0.963
G10	0.4	0.0	0.000
G2	0.4	0.0	0.000

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
G2-1	11.0	0.0	0.000
G3	0.4	0.0	0.000
G3-1	11.0	0.0	0.000
G4	11.0	0.0	0.000
G5	0.4	0.0	0.000
G6	0.4	0.0	0.000
G7-8	0.4	0.0	0.000
Gon	11.0	10.6	0.966
Gonway	11.0	10.6	0.965
Ijew	11.0	10.4	0.948
Junct1	11.0	10.6	0.965
Junct2	11.0	10.6	0.964
Junct5	11.0	10.6	0.963
MFATSolar	11.0	11.6	1.056
Menen_E1	11.0	10.6	0.965
Menen_E1(1)	11.0	10.2	0.929
Menen_N1	11.0	10.4	0.947
Menen_S2	11.0	10.6	0.960
PS3.3kV-A	3.3	3.2	0.966
PS3.3kV-B	3.3	3.2	0.966
Pago	11.0	10.6	0.966
RPC1	11.0	10.3	0.937
RPC3RPC2Ronphos	11.0	10.2	0.926
RehabWorkshops	11.0	10.2	0.929
Ronave	11.0	10.5	0.951
Terrace	11.0	10.6	0.960
TheBay	11.0	10.4	0.947
UAESolar	11.0	10.6	0.964
Waboe	11.0	10.5	0.959

Table 17 Thermal overloading results at field feeder out of service- scenario 1

Name	HV-Side	LV-Side	HV-Side V p.u.	LV-Side Vn p.u.	Loading (%)
Line(32) - Express Feeder	MFATSolar	11kVSolar	1.056	0.968	107.9
2-Winding Transformer	MFATSolar	Terminal	1.056	1.055	85.3
2-Winding Transformer - UAESolar	UAESolar	Terminal(6)	0.964	1.000	24.9
BESS1 2-Winding Transformer	ADBSolar	BESS1 Terminal	1.056	1.100	82.0
BESS2 2-Winding Transformer	ADBSolar	BESS2 Terminal	1.056	1.100	73.2
PV1 2-Winding Transformer	ADBSolar	PV1 Terminal	1.056	1.265	94.8
PV2 2-Winding Transformer	ADBSolar	PV2 Terminal	1.056	1.265	94.8
PV3 2-Winding Transformer	ADBSolar	PV3 Terminal	1.056	1.266	75.8
T1	11kVEast	PS3.3kV-A	0.968	0.966	6.8
T2	11kVSouth	PS3.3kV-A	0.968	0.966	6.8
T3	11kVNorth	PS3.3kV-B	0.968	0.966	6.8
T4	- 11kVField	PS3.3kV-B	0.966	0.966	0.0

4.1.1.2 Contingency at Express Feeder

Following are the results for express feeder out of service.

- No voltage issues have been identified.
- Line(5) - Field Feeder is overloaded at 101.4%.

Table 18 Load flow results at express feeder out of service- scenario 1

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
11kVEast	11.0	11.0	1.003
11kVField	11.0	11.0	1.003
11kVNorth	11.0	11.0	1.003
11kVSolar	11.0	11.0	1.003
11kVSouth	11.0	11.0	1.003
ADBSolar	11.0	11.7	1.062

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
Airport	11.0	11.0	1.000
Anabar	11.0	10.8	0.985
Arijejen	11.0	11.0	1.000
Civic	11.0	11.0	1.001
CommandRidge	11.0	11.1	1.010
DomSub	11.0	11.1	1.010
EUSolar	11.0	11.5	1.050
FreshCentre	11.0	11.0	1.000
FreshCentre_S1	11.0	11.0	0.997
FuelTankFarm	11.0	11.1	1.010
G10	0.4	0.0	0.000
G2	0.4	0.0	0.000
G2-1	11.0	0.0	0.000
G3	0.4	0.0	0.000
G3-1	11.0	0.0	0.000
G4	11.0	0.0	0.000
G5	0.4	0.0	0.000
G6	0.4	0.0	0.000
G7-8	0.4	0.0	0.000
Gon	11.0	11.0	1.000
Gonway	11.0	11.0	1.000
Ijew	11.0	10.8	0.983
Junct1	11.0	11.0	1.000
Junct2	11.0	11.0	0.999
Junct5	11.0	11.0	0.998
MFATSolar	11.0	11.7	1.062
Menen_E1	11.0	11.0	1.000
Menen_E1(1)	11.0	11.5	1.050
Menen_N1	11.0	10.8	0.983
Menen_S2	11.0	10.9	0.995
PS3.3kV-A	3.3	3.3	1.001
PS3.3kV-B	3.3	3.3	1.001
Pago	11.0	11.0	1.001
RPC1	11.0	11.6	1.057
RPC3RPC2Ronphos	11.0	11.5	1.047
RehabWorkshops	11.0	11.5	1.050
Ronave	11.0	10.9	0.987
Terrace	11.0	10.9	0.995
TheBay	11.0	10.8	0.983
UAESolar	11.0	11.0	0.999
Waboe	11.0	10.9	0.994

Table 19 Thermal overloading results at express feeder out of service- scenario 1

Name	HV-Side	LV-Side	HV-Side V p.u.	LV-Side Vn p.u.	Loading (%)
Line(5) - Field Feeder	RPC1	ADBSolar	1.057	1.062	101.0
2-Winding Transformer	MFATSolar	Terminal	1.062	1.061	84.9
2-Winding Transformer - UAESolar	UAESolar	Terminal(6)	0.999	1.036	24
BESS1 2-Winding Transformer	ADBSolar	BESS1 Terminal	1.062	1.1	68.9
BESS2 2-Winding Transformer	ADBSolar	BESS2 Terminal	1.062	1.1	64.1
PV1 2-Winding Transformer	ADBSolar	PV1 Terminal	1.062	1.272	94.3
PV2 2-Winding Transformer	ADBSolar	PV2 Terminal	1.062	1.272	94.3
PV3 2-Winding Transformer	ADBSolar	PV3 Terminal	1.062	1.273	75.4
T1	11kVEast	PS3.3kV-A	1.003	1.001	6.6
T2	11kVSouth	PS3.3kV-A	1.003	1.001	6.6
T3	11kVNorth	PS3.3kV-B	1.003	1.001	6.6
T4	- 11kVField	PS3.3kV-B	1.001	1.001	0

4.1.2 Scenario 2

In **Scenario 2:** Annual minimum load of 2 MW @ 0.93 p.f. 100% supply from BESS (in grid forming mode) and PV,

- No voltage and thermal loading issues have been identified.

Table 20 Scenario 2 load flow results

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
11kVEast	11.0	11.1	1.008
11kVField	11.0	11.1	1.008
11kVNorth	11.0	11.1	1.008
11kVSolar	11.0	11.1	1.008
11kVSouth	11.0	11.1	1.008
ADBSolar	11.0	11.2	1.015
Airport	11.0	11.1	1.007
Anabar	11.0	11.0	1.003
Arijejen	11.0	11.1	1.007
Civic	11.0	11.1	1.007
CommandRidge	11.0	11.1	1.009
DomSub	11.0	11.1	1.009
EUSolar	11.0	11.1	1.012
FreshCentre	11.0	11.1	1.007
FreshCentre_S1	11.0	11.1	1.007
FuelTankFarm	11.0	11.1	1.009
G10	0.4	0.0	0.000
G2	0.4	0.0	0.000
G2-1	11.0	0.0	0.000
G3	0.4	0.0	0.000
G3-1	11.0	0.0	0.000
G4	11.0	0.0	0.000
G5	0.4	0.0	0.000
G6	0.4	0.0	0.000
G7-8	0.4	0.0	0.000
Gon	11.0	11.1	1.007
Gonway	11.0	11.1	1.007
Ijew	11.0	11.0	1.003
Junct1	11.0	11.1	1.007
Junct2	11.0	11.1	1.007
Junct5	11.0	11.1	1.007
MFATSolar	11.0	11.2	1.015
Menen_E1	11.0	11.1	1.007
Menen_E1(1)	11.0	11.1	1.012
Menen_N1	11.0	11.0	1.002
Menen_S2	11.0	11.1	1.007
PS3.3kV-A	3.3	3.3	1.007
PS3.3kV-B	3.3	3.3	1.007
Pago	11.0	11.1	1.007
RPC1	11.0	11.2	1.014
RPC3RPC2Ronphos	11.0	11.1	1.012
RehabWorkshops	11.0	11.1	1.012
Ronave	11.0	11.0	1.004
Terrace	11.0	11.1	1.007
TheBay	11.0	11.0	1.002
UAESolar	11.0	11.1	1.008
Waboe	11.0	11.1	1.005

Table 21 Scenario 2 thermal overloading results

Name	HV-Side	LV-Side	HV-Side V p.u.	LV-Side V p.u.	Loading (%)
2-Winding Transformer	MFATSolar	Terminal	1.015	1.015	26.6
2-Winding Transformer - UAESolar	UAESolar	Terminal(6)	1.008	1.045	23.8
BESS1 2-Winding Transformer	ADBSolar	BESS1 Terminal	1.015	1.025	19.3
BESS2 2-Winding Transformer	ADBSolar	BESS2 Terminal	1.015	1.025	16.3
PV1 2-Winding Transformer	ADBSolar	PV1 Terminal	1.015	1.218	22.2
PV2 2-Winding Transformer	ADBSolar	PV2 Terminal	1.015	1.218	22.2
PV3 2-Winding Transformer	ADBSolar	PV3 Terminal	1.015	1.218	17.7
T1	11kVEast	PS3.3kV-A	1.008	1.007	1.7
T2	11kVSouth	PS3.3kV-A	1.008	1.007	1.7

Name	HV-Side	LV-Side	HV-Side V p.u.	LV-Side V p.u.	Loading (%)
T3	11kVNorth	PS3.3kV-B	1.008	1.007	1.7
T4	- 11kVField	PS3.3kV-B	1.007	1.007	0

4.1.3 Scenario 3

In **Scenario 3:** Annual maximum load of 7.5 MW @ 0.93 p.f. 100% supply from diesel power station (in existing location),

- The highest voltages in the network can be found at G7-8 (1.044 p.u.), G2 and G5 (1.031 p.u.).
- The lowest voltage in the network can be found at RPC3RPC2Ronphos (0.899 p.u.).
- The 2-winding transformers at T1, T2 and T3 are overloaded at ~113.6% loading.

Table 22 Scenario 3 load flow results

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
11kVEast	11.0	10.2	0.927
11kVField	11.0	10.2	0.927
11kVNorth	11.0	10.2	0.927
11kVSolar	11.0	10.2	0.927
11kVSouth	11.0	10.2	0.927
ADBSolar	11.0	10.0	0.911
Airport	11.0	10.2	0.924
Anabar	11.0	10.0	0.907
Arijejen	11.0	10.2	0.923
Civic	11.0	10.2	0.925
CommandRidge	11.0	10.2	0.924
DomSub	11.0	10.2	0.924
EUSolar	11.0	9.9	0.902
FreshCentre	11.0	10.2	0.924
FreshCentre_S1	11.0	10.1	0.919
FuelTankFarm	11.0	10.2	0.924
G10	0.4	0.4	1.000
G2	0.4	0.4	1.031
G2-1	11.0	11.0	1.000
G3	0.4	0.0	0.000
G3-1	11.0	0.0	0.000
G4	11.0	10.6	0.965
G5	0.4	0.4	1.031
G6	0.4	0.0	0.000
G7-8	0.4	0.4	1.044
Gon	11.0	10.2	0.924
Gonway	11.0	10.2	0.924
Ijew	11.0	10.0	0.906
Junct1	11.0	10.2	0.923
Junct2	11.0	10.1	0.922
Junct5	11.0	10.1	0.920
MFATSolar	11.0	10.0	0.911
Menen_E1	11.0	10.2	0.923
Menen_E1(1)	11.0	9.9	0.902
Menen_N1	11.0	10.0	0.905
Menen_S2	11.0	10.1	0.917
PS3.3kV-A	3.3	3.2	0.964
PS3.3kV-B	3.3	3.2	0.964
Pago	11.0	10.2	0.924
RPC1	11.0	10.0	0.911
RPC3RPC2Ronphos	11.0	9.9	0.899
RehabWorkshops	11.0	9.9	0.902
Ronave	11.0	10.0	0.909
Terrace	11.0	10.1	0.917
TheBay	11.0	10.0	0.905
UAESolar	11.0	10.1	0.921

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
Waboe	11.0	10.1	0.917

Table 23 Scenario 3 thermal overloading results

Name	HV-Side	LV-Side	HV-Side V p.u.	LV-Side Vn p.u.	Loading (%)
CATG7TX	PS3.3kV-A	G7-8	0.964	1.044	0.1
GEN 2A & G2B Transformer	PS3.3kV-B	G2	0.964	1.031	85.6
GEN 4 Rus Transformer	G4	PS3.3kV-B	0.965	0.964	5.7
GEN 5 TX	PS3.3kV-B	G5	0.964	1.031	85.6
MAN2TX	G2-1	PS3.3kV-B	1.000	0.964	81.3
T1[2]	11kVEast	PS3.3kV-A	0.927	0.964	113.6
T2	11kVSouth	PS3.3kV-A	0.927	0.964	113.6
T3	11kVNorth	PS3.3kV-B	0.927	0.964	113.8
T4	- 11kVField	PS3.3kV-B	0.965	0.965	0

4.1.4 Scenario 4

In **Scenario 4:** Annual minimum load of 2 MW @ 0.93 p.f. 100% supply from diesel power station (in existing location),

- No voltage and thermal loading issues have been identified.
- The highest voltage in the network are at G7-8 (1.062 p.u.).

Table 24 Scenario 4 load flow results

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
11kVEast	11.0	10.7	0.971
11kVField	11.0	10.7	0.971
11kVNorth	11.0	10.7	0.971
11kVSolar	11.0	10.7	0.971
11kVSouth	11.0	10.7	0.971
ADBSolar	11.0	10.6	0.967
Airport	11.0	10.7	0.970
Anabar	11.0	10.6	0.966
Arijejen	11.0	10.7	0.970
Civic	11.0	10.7	0.970
CommandRidge	11.0	10.7	0.971
DomSub	11.0	10.7	0.971
EUSolar	11.0	10.6	0.965
FreshCentre	11.0	10.7	0.970
FreshCentre_S1	11.0	10.7	0.969
FuelTankFarm	11.0	10.7	0.971
G10	0.4	0.4	1.018
G2	0.4	0.4	1.028
G2-1	11.0	11.0	1.000
G3	0.4	0.0	0.000
G3-1	11.0	0.0	0.000
G4	11.0	0.0	0.000
G5	0.4	0.0	0.000
G6	0.4	0.0	0.000
G7-8	0.4	0.4	1.062
Gon	11.0	10.7	0.970
Gonway	11.0	10.7	0.970
Ijew	11.0	10.6	0.966
Junct1	11.0	10.7	0.970
Junct2	11.0	10.7	0.970
Junct5	11.0	10.7	0.970
MFATSolar	11.0	10.6	0.967
Menen_E1	11.0	10.7	0.970
Menen_E1(1)	11.0	10.6	0.965

[2] There will be no overloading at T1, T2, and T3 if T4 is connected.

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
Menen_N1	11.0	10.6	0.966
Menen_S2	11.0	10.7	0.969
PS3.3kV-A	3.3	3.2	0.981
PS3.3kV-B	3.3	3.2	0.981
Pago	11.0	10.7	0.970
RPC1	11.0	10.6	0.967
RPC3RPC2Ronphos	11.0	10.6	0.964
RehabWorkshops	11.0	10.6	0.965
Ronave	11.0	10.6	0.967
Terrace	11.0	10.7	0.969
TheBay	11.0	10.6	0.966
UAESolar	11.0	10.7	0.970
Waboe	11.0	10.7	0.969

Table 25 Scenario 4 thermal overloading results

Name	HV-Side	LV-Side	HV-Side V p.u.	LV-Side Vn p.u.	Loading (%)
GEN 2A & G2B Transformer	PS3.3kV-B	G2	0.981	1.028	47.3
MAN2TX	G2-1	PS3.3kV-B	1	0.981	43.8
T1	11kVEast	PS3.3kV-A	0.971	0.981	30.8
T2	11kVSouth	PS3.3kV-A	0.971	0.981	30.8
T3	11kVNorth	PS3.3kV-B	0.971	0.981	30.8
T4	- 11kVField	PS3.3kV-B	0.981	0.981	0

4.1.5 Scenario 5

In **Scenario 5:** Moderate load of 5.5 MW @ 0.93 p.f., with 52% of supply coming from PV and 48% from diesel generation**.**

- No overvoltage and thermal overloading of the transformers were observed.

Table 26 Scenario 5 load flow results

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
11kVEast	11.0	10.7	0.971
11kVField	11.0	10.7	0.971
11kVNorth	11.0	10.7	0.971
11kVSolar	11.0	10.7	0.971
11kVSouth	11.0	10.7	0.971
ADBSolar	11.0	10.6	0.967
Airport	11.0	10.7	0.970
Anabar	11.0	10.6	0.966
Arijejen	11.0	10.7	0.970
Civic	11.0	10.7	0.970
CommandRidge	11.0	10.7	0.971
DomSub	11.0	10.7	0.971
EUSolar	11.0	10.6	0.965
FreshCentre	11.0	11.1	1.008
FreshCentre_S1	11.0	11.1	1.008
FuelTankFarm	11.0	11.1	1.008
G10	11.0	11.1	1.008
G2	11.0	11.1	1.008
G2-1	11.0	11.1	1.013
G3	11.0	11.1	1.006
G3-1	11.0	10.9	0.995
G4	11.0	11.1	1.005
G5	11.0	11.1	1.006
G6	11.0	11.1	1.008
G7-8	11.0	11.1	1.008
Gon	11.0	11.1	1.006
Gonway	11.0	11.1	1.006
Ijew	11.0	11.0	1.003

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
Junct1	11.0	11.1	1.008
Junct2	0.4	0.4	1.058
Junct5	0.4	0.4	1.058
MFATSolar	11.0	12.1	1.100
Menen_E1	0.4	0.0	0.000
Menen_E1(1)	11.0	0.0	0.000
Menen_N1	11.0	11.2	1.019
Menen_S2	0.4	0.4	1.063
PS3.3kV-A	0.4	0.0	0.000
PS3.3kV-B	0.4	0.4	1.103
Pago	11.0	11.1	1.006
RPC1	11.0	11.1	1.006
RPC3RPC2Ronphos	11.0	10.9	0.993
RehabWorkshops	11.0	11.1	1.006
Ronave	11.0	11.1	1.005
Terrace	11.0	11.0	1.004
TheBay	11.0	11.1	1.013
UAESolar	11.0	11.1	1.005
Waboe	11.0	11.1	1.006

Table 27 Scenario 5 thermal overloading results

Name	HV-Side	LV-Side	HV-Side V p.u.	LV-Side Vn p.u.	Loading (%)
2-Winding Transformer	MFATSolar	Terminal	1.013	1.012	69.2
2-Winding Transformer - UAESolar	UAESolar	Terminal(6)	1.005	1.042	15.9
BESS1 2-Winding Transformer	ADBSolar	BESS1 Terminal	1.013	1.025	20.3
BESS2 2-Winding Transformer	ADBSolar	BESS2 Terminal	1.013	1.025	20.3
GEN 5 TX	PS3.3kV-B	G5	1.019	1.063	58.6
MAN2TX	G2-1	PS3.3kV-B	1.1	1.019	55.2
PV1 2-Winding Transformer	ADBSolar	PV1 Terminal	1.013	1.215	34.6
PV2 2-Winding Transformer	ADBSolar	PV2 Terminal	1.013	1.215	34.6
PV3 2-Winding Transformer	ADBSolar	PV3 Terminal	1.013	1.215	27.6
T1	11kVEast	PS3.3kV-A	1.008	1.019	34.7
T2	11kVSouth	PS3.3kV-A	1.008	1.019	34.7
T3	11kVNorth	PS3.3kV-B	1.008	1.019	34.7
T4	- 11kVField	PS3.3kV-B	1.019	1.019	0

4.1.6 Scenario 6

Scenario 6: Annual minimum load of 2 MW @ 0.93 p.f. 100% supply from BESS (PV off and diesel off mode);

- No overvoltage and thermal overloading of the transformers were observed.

Table 28 Scenario 6 load flow results

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
11kVEast	11.0	11.1	1.006
11kVField	11.0	11.1	1.006
11kVNorth	11.0	11.1	1.006
11kVSolar	11.0	11.1	1.006
11kVSouth	11.0	11.1	1.006
ADBSolar	11.0	11.2	1.015
Airport	11.0	11.1	1.006
Anabar	11.0	11.0	1.002
Arijejen	11.0	11.1	1.005
Civic	11.0	11.1	1.006
CommandRidge	11.0	11.1	1.007
DomSub	11.0	11.1	1.007
EUSolar	11.0	11.1	1.012
FreshCentre	11.0	11.1	1.005
FreshCentre_S1	11.0	11.0	1.004
FuelTankFarm	11.0	11.1	1.007

Name	Nom.L-L kV.	Voltage kV	Voltage p.u.
G10	0.4	0.0	0.000
G2	0.4	0.0	0.000
G2-1	11.0	0.0	0.000
G3	0.4	0.0	0.000
G3-1	11.0	0.0	0.000
G4	11.0	0.0	0.000
G5	0.4	0.0	0.000
G6	0.4	0.0	0.000
G7-8	0.4	0.0	0.000
Gon	11.0	11.1	1.005
Gonway	11.0	11.1	1.005
Ijew	11.0	11.0	1.001
Junct1	11.0	11.1	1.005
Junct2	11.0	11.1	1.005
Junct5	11.0	11.1	1.005
MFATSolar	11.0	11.2	1.015
Menen_E1	11.0	11.1	1.005
Menen_E1(1)	11.0	11.1	1.012
Menen_N1	11.0	11.0	1.001
Menen_S2	11.0	11.0	1.004
PS3.3kV-A	3.3	3.3	1.006
PS3.3kV-B	3.3	3.3	1.006
Pago	11.0	11.1	1.006
RPC1	11.0	11.2	1.014
RPC3RPC2Ronphos	11.0	11.1	1.011
RehabWorkshops	11.0	11.1	1.012
Ronave	11.0	11.0	1.002
Terrace	11.0	11.0	1.004
TheBay	11.0	11.0	1.001
UAESolar	11.0	11.1	1.005
Waboe	11.0	11.0	1.004

Table 29 ***Scenario 6 thermal overloading results***

Name	HV-Side	LV-Side	HV-Side V p.u.	LV-Side Vn p.u.	Loading (%)
BESS1 2-Winding Transformer	ADBSolar	BESS1 Terminal	1.015	1.025	80.7
BESS2 2-Winding Transformer	ADBSolar	BESS2 Terminal	1.015	1.025	16.8
T1	11kVEast	PS3.3kV-A	1.006	1.006	1.7
T2	11kVSouth	PS3.3kV-A	1.006	1.006	1.7
T3	11kVNorth	PS3.3kV-B	1.006	1.006	1.7
T4	- 11kVField	PS3.3kV-B	1.006	1.006	1.7

4.2 Fault Study Results

The results presented below are for the maximum and minimum fault level cases. Three-phase short-circuit and single phase to ground faults are performed at every bus within the NUC network. Various fault contribution levels were considered for the solar PV and BESS. Several variations in the network configuration, i.e., whether FF and/or EF are closed or open, were also considered.

The results of the fault currents for three-phase short-circuit and single phase to ground faults at individual buses are shown in the following sections. As per DQ01-001 Electrical Single Line Diagram2022.09.23 11 kV solar busbar is rated to 31.5 kA for 3 seconds. For each scenario, the ADBSolar fault currents are compared with this rating of the busbar.

4.2.1 Summary of Fault Study

- For all six scenarios simulated, the ADBSolar fault currents are within the rating of the busbar.
- Maximum fault currents are observed during scenario 5 at mixed operation of renewables and diesel. Minimum fault currents are observed during scenarios 6 at BESS only (PV and diesel off) operation.
- The maximum fault currents at the 11kV solar busbar even for shorter durations are well under the limit of 31.5 kA.

Table 30 and Table 31 provide the maximum and minimum three-phase fault levels, respectively, calculated for all the buses in the network.

- Table 30 may be used as reference to determine whether the maximum fault currents for all buses are within the fault current ratings of their respective circuit breakers and switchgears. serves as a reference for the assessment of overcurrent protection to ensure that the protective devices will operate at the lowest possible level of short-circuit current that can occur. A separate Nauru Protection System Assessment report contains the said assessment.

Table 30 Summary of Maximum 3-Phase Fault Levels – BESS fault contribution 2.0 p.u , Solar contribution 1.5 p.u

Name	S1 Ik" kA	S3 Ik" kA	S5 Ik" kA	Maximum kA (Scenario 5)
11kVEast	0.984	1.713	2.671	2.671
11kVField	0.984	1.713	2.671	2.671
11kVNorth	0.984	1.713	2.671	2.671
11kVSolar	0.984	1.713	2.671	2.671
11kVSouth	0.984	1.713	2.671	2.671
ADBSolar	1.103	1.451	2.538	2.538
Airport	0.949	1.630	2.454	2.454
Anabar	0.738	1.110	1.418	1.418
Arijejen	0.954	1.634	2.474	2.474
Civic	0.962	1.661	2.535	2.535
CommandRidge	0.984	1.641	2.561	2.561
DomSub	0.984	1.641	2.562	2.562
EUSolar	0.932	1.186	1.803	1.803
FreshCentre	0.931	1.584	2.342	2.342
FreshCentre_S1	0.851	1.380	1.896	1.896
FuelTankFarm	0.984	1.641	2.562	2.562
G10	0.000	14.665	26.305	26.305
G2	0.000	31.454	34.184	34.184
G2-1	0.000	1.982	2.268	2.268
G3	0.000	0.000	0.000	0.000
G3-1	0.000	0.000	0.000	0.000
G4	0.000	2.249	2.990	2.990
G5	0.000	31.667	34.418	34.418
G6	0.000	0.000	0.000	0.000
G7-8	0.000	55.602	75.038	75.038
Gon	0.946	1.622	2.436	2.436
Gonway	0.933	1.589	2.354	2.354
Ijew	0.715	1.065	1.337	1.337
Junct1	0.936	1.581	2.354	2.354
Junct2	0.904	1.495	2.163	2.163
Junct5	0.871	1.425	1.997	1.997
MFATSolar	1.103	1.451	2.538	2.538
Menen_E1	0.891	1.487	2.114	2.114
Menen_E1(1)	0.864	1.082	1.566	1.566
Menen_N1	0.645	0.921	1.113	1.113
Menen_S2	0.738	1.114	1.416	1.416
PS3.3kV-A	2.857	7.726	10.497	10.497
PS3.3kV-B	2.857	7.726	10.497	10.497
Pago	0.951	1.633	2.463	2.463
RPC1	1.090	1.451	2.508	2.508

Name	S1 Ik" kA	S3 Ik" kA	S5 Ik" kA	Maximum kA (Scenario 5)
RPC3RPC2Ronphos	0.972	1.253	1.961	1.961
RehabWorkshops	1.008	1.311	2.113	2.113
Ronave	0.777	1.198	1.570	1.570
Terrace	0.790	1.231	1.618	1.618
TheBay	0.671	0.973	1.192	1.192
UAESolar	0.893	1.470	2.104	2.104
Waboe	0.881	1.445	2.048	2.048

Table 31 Summary of Minimum 3-Phase Fault Levels – BESS fault contribution = 2.0 p.u., Solar contribution = 1.5 p.u.

Name	S2 Ik" kA	S4 Ik" kA	S5 Ik" kA	S6 Ik" kA	Minimum kA (Scenario 6)
11kVEast	0.868	0.870	2.057	0.277	0.277
11kVField	0.868	0.870	2.057	0.272	0.272
11kVNorth	0.868	0.870	2.057	0.240	0.240
11kVSolar	0.868	0.870	2.057	0.238	0.238
11kVSouth	0.868	0.870	2.057	0.273	0.273
ADBSolar	0.960	0.789	1.407	0.253	0.253
Airport	0.838	0.844	1.148	0.275	0.275
Anabar	0.655	0.663	0.789	0.275	0.275
Arijejen	0.843	0.846	1.792	0.252	0.252
Civic	0.850	0.854	1.461	0.222	0.222
CommandRidge	0.868	0.848	1.830	0.246	0.246
DomSub	0.868	0.849	1.831	0.275	0.275
EUSolar	0.820	0.694	0.919	0.000	0.000
FreshCentre	0.821	0.829	0.848	0.000	0.000
FreshCentre_S1	0.750	0.759	1.006	0.000	0.000
FuelTankFarm	0.868	0.849	1.831	0.000	0.000
G10	0.000	15.440	27.080	0.000	0.000
G2	0.000	22.083	38.453	0.000	0.000
G2-1	0.000	1.197	1.781	0.000	0.000
G3	0.000	0.000	0.000	0.000	0.000
G3-1	0.000	0.000	0.000	0.000	0.000
G4	0.000	0.000	1.750	0.237	0.237
G5	0.000	0.000	38.617	0.224	0.224
G6	0.000	0.000	0.000	0.228	0.228
G7-8	0.000	25.473	100.504	0.270	0.270
Gon	0.835	0.841	1.088	0.265	0.265
Gonway	0.823	0.830	0.874	0.253	0.253
Ijew	0.633	0.643	0.689	0.272	0.272
Junct1	0.828	0.830	1.642	0.191	0.191
Junct2	0.800	0.802	1.429	0.243	0.243
Junct5	0.769	0.776	1.140	0.214	0.214
MFATSolar	0.960	0.789	1.407	0.228	0.228
Menen_E1	0.785	0.796	0.518	0.916	0.916
Menen_E1(1)	0.761	0.651	0.779	0.916	0.916
Menen_N1	0.571	0.580	0.556	0.241	0.241
Menen_S2	0.651	0.660	0.711	0.272	0.272
PS3.3kV-A	2.549	3.345	12.818	0.258	0.258
PS3.3kV-B	2.549	3.345	12.818	0.262	0.262
Pago	0.839	0.845	1.177	0.245	0.245
RPC1	0.950	0.789	1.403	0.237	0.237
RPC3RPC2Ronphos	0.854	0.720	1.021	0.219	0.219
RehabWorkshops	0.884	0.742	1.120	0.261	0.261
Ronave	0.690	0.698	0.902	0.262	0.262
Terrace	0.697	0.706	0.831	0.277	0.277
TheBay	0.594	0.604	0.602	0.272	0.272
UAESolar	0.789	0.793	1.312	0.240	0.240
Waboe	0.780	0.786	1.319	0.238	0.238

4.2.2 Fault study with solar interconnector failure contingency event

Table 32The impact of opening the interconnector-field tie for different fault scenarios which may be required in a solar interconnector failure contingency event is assessed in this section.

The fault levels at ADB solar, 11 kV field, Menen_E1(1) and Menen_N1 buses are presented in Table 32and Table 33 below during following network arrangements.

Table 32 Diesel OFF fault levels (Scenario 1) – BESS fault contribution = 2.0 p.u., Solar fault contribution = 1.5 p.u.

Network Configuration		Fault Location	Load Current	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
NOP	**FF**						
Open	Closed	ADB Solar	0.366	0.959	18.3	0.618	3.9
		11kV Field	0.255	0.860	16.4	0.661	4.2
		Menen_E1(1)	0.000	0.724	13.8	0.443	2.8
		Menen_N1	0.000	0.519	9.9	0.328	2.1
Closed	Closed	ADB Solar	0.365	0.959	18.3	0.631	4.0
		11kV Field	0.193	0.887	16.9	0.671	4.3
		Menen_E1(1)	0.060	0.867	16.5	0.572	3.6
		Menen_N1	0.060	0.867	16.5	0.572	3.6
Closed	Open	ADB Solar	0.399	0.955	18.2	0.538	3.4
		11kV Field	0.438	0.806	15.4	0.626	4.0
		Menen_E1(1)	0.070	0.761	14.5	0.519	3.3
		Menen_N1	0.093	0.761	14.5	0.519	3.3

Table 33 Diesel ON fault levels (Scenario 3) – BESS fault contribution = 2.0 p.u., Solar fault contribution = 1.5 p.u.

Network Configuration		Fault Location	Load Current	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik"A kA	1 ph Sk" A MVA
NOP	**FF**						
Open	Closed	ADB Solar	0.079	1.380	26.3	1.187	7.5
		11kV Field	0.174	1.676	31.9	1.764	11.2
		Menen_E1(1)	0.000	0.973	18.5	0.688	4.4
		Menen_N1	0.000	0.803	15.3	0.512	3.2
Closed	Closed	ADB Solar	0.054	1.442	27.5	1.270	8.1
		11kV Field	0.124	1.676	31.9	1.764	11.2
		Menen_E1(1)	0.050	1.526	29.1	1.200	7.6
		Menen_N1	0.076	1.526	29.1	1.200	7.6
Closed	Open	ADB Solar	0.000	1.154	22.0	0.905	5.7
		11kV Field	0.102	1.676	31.9	1.765	11.2
		Menen_E1(1)	0.073	1.522	29.0	1.168	7.4
		Menen_N1	0.096	1.522	29.0	1.168	7.4

5. Conclusion and Next Steps

5.1 Thermal Constraints and Voltage Regulation

Normal Conditions

Six operation scenarios were considered in this study: minimum and maximum demand scenarios with either renewable only or diesel generation only, as well as a moderate load scenario with a mix of renewable and diesel generators in operation, and a minimum load scenario with BESS only.

No overvoltages were observed for the operation scenarios considered. At diesel only at maximum load operation, undervoltage was observed at RPC3RPC2Ronphos 11kV bus, which was at 9.89 kV (0.899 p.u.). In the same scenario, three main transformers T1, T2 and T3 were all overloaded at ~114%. This is however due to the load growth modelled and not associated with the connection of the solar or BESS.

Contingency Events

In Diesel Off mode at maximum demand (Scenario 1), two contingency events were simulated: (1) Express Feeder Network Configuration, in which the Field Feeder is open or faulted, and (2) Field Feeder Network Configuration, in which the Express Feeder is open or faulted.

During the Express Feeder network configuration (i.e. Field feeder open or faulted) and maximum load when running in diesel off mode (scenario 1), the Solar Interconnector Express Feeder conductor is overloaded (108.5%) based on the Krypton conductor rating of 410 A[9]. Conversely, during the Field Feeder network configuration (i.e., Express Feeder open or faulted) and maximum load when running in diesel off mode (scenario 1), the Field Feeder conductor is overloaded (101.4%). It is therefore recommended that a protection or control system be put in place to prevent this overload and dispatch additional gensets if required.

It is also recommended that the System to be nominally operated in Distributed Generation network configuration (i.e., both feeders closed).

Study recommendations and future works:

The primary objective of this steady state modelling is to ensure the equipment will not have thermal overloading, voltage regulation issues at different load and generation dispatch scenarios. GHD has developed the DIgSILENT model based on information made available by NUC. However, the effective As Built information had a number of limitations and assumptions to be made. To further improve the model, a process of validation of the models could be undertaken by NUC including:

- Generator governor and real power capability curves.
- Transformer tap settings.
- Network configuration verification
- Equipment fault ratings
- Detailed load measurements per transformation (rather than scaling based on nameplate rating)

5.2 Fault Study

Fault studies were conducted to determine the minimum and maximum fault currents from the six operational scenarios.[10] Among the six scenarios, maximum fault currents were observed for the mixed operation of renewables and diesel (Scenario 5), while minimum fault currents were observed for the BESS only operation (Scenario 6).

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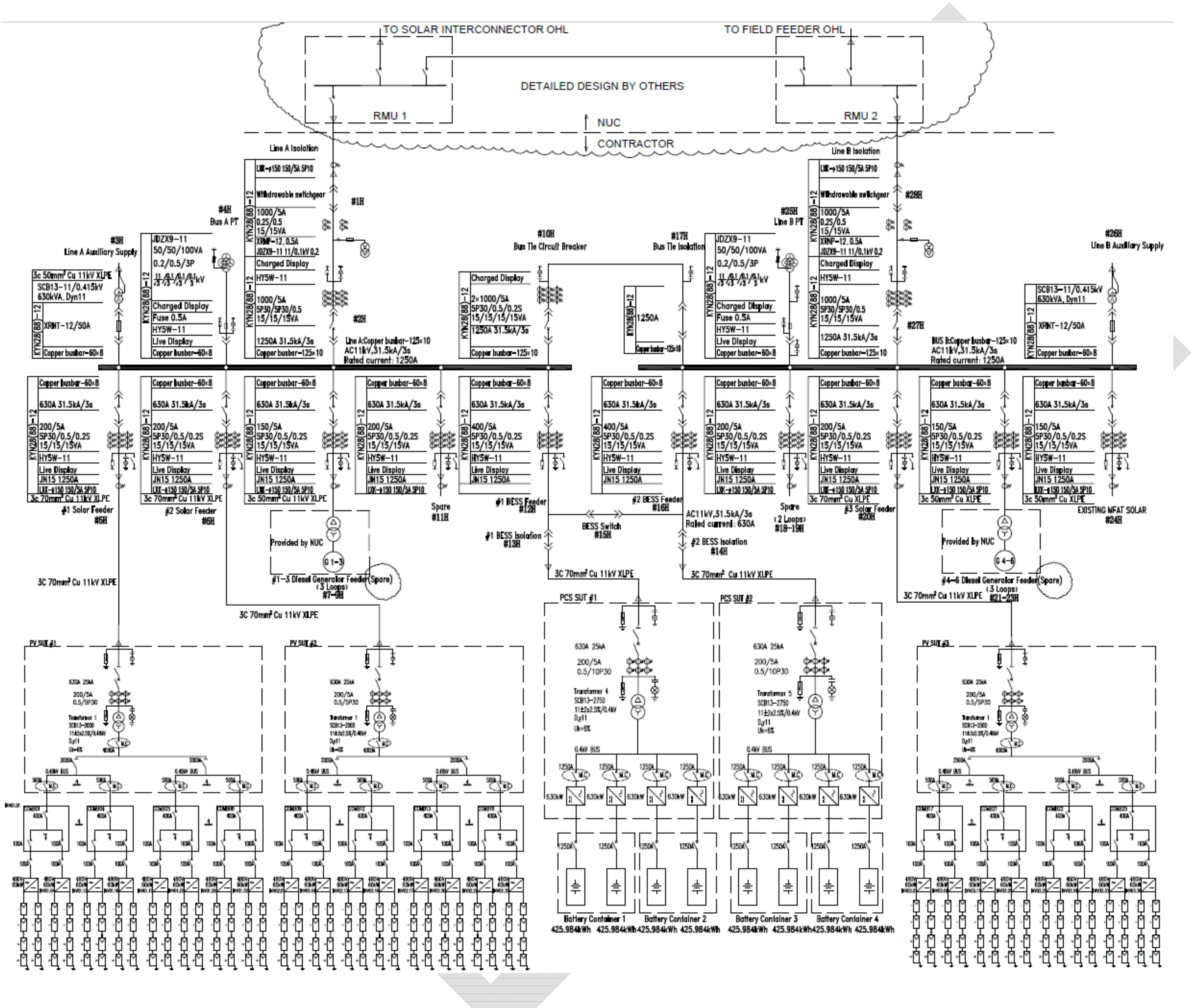
[9] But at 1m/s wind-speed, 35 degrees Celsius and industrialised derating is 459 A (8.7 MVA @ 11 kV)

[10] Minimum short-circuit analyses for the minimum demand scenarios (Scenarios 2 and 4) were re-run to accommodate new information on transformer impedances, UAE Solar Farm location, and dispatch considerations. Additional maximum and minimum short-circuit analyses were also performed for the moderate load scenario (Scenario 5).

Appendix A

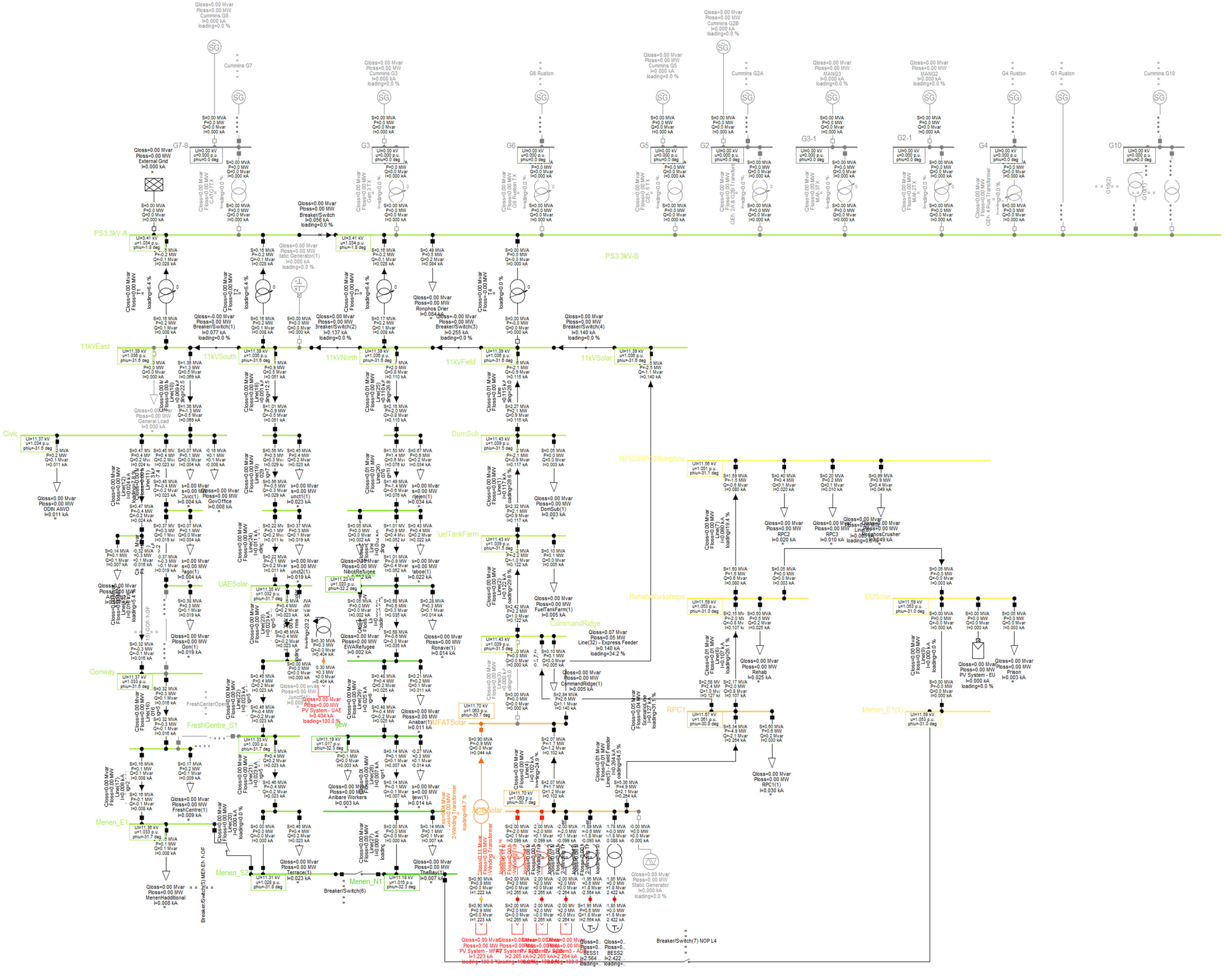
EPC Contractor Solar & BESS SLD


TO SOLAR INTERCONNECTOR OHL
TO FIELD FEEDER OHL
DETAILED DESIGN BY OTHERS
RMU 1
RMU 2
NUC
CONTRACTOR
Line A Isolation
Line B Isolation
#1H
#28H
#4H Bus A PT
#25H Line B PT
#3H Line A Auxiliary Supply
#26H Line B Auxiliary Supply
#10H Bus Tie Circuit Breaker
#17H Bus Tie Isolation
Provided by NUC
#1-3 Diesel Generator Feeder (3 Loops) (Spare)
#4-6 Diesel Generator Feeder (3 Loops) (Spare)
BESS Switch #15H
#1 BESS Isolation #13H
#2 BESS Isolation #14H
PCS SUT #1
PCS SUT #2
PV SUT #1
PV SUT #2
PV SUT #3
Battery Container 1
Battery Container 2
Battery Container 3
Battery Container 4
EXISTING MFAT SOLAR #24H

Appendix B

Load Flow SLD

Figure 1 *Scenario 1*



Appendix C

Fault Level One Line Diagram and Detailed Fault Study Results

C-1 Maximum Short-Circuit Analyses

Table 34 Scenario 1 Maximum Short-Circuit Currents, BESS Fault contribution = 2.0 p.u., PV Fault contribution = 1.5 p.u. (NOP open, FF closed, EF closed)

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
11kVEast	0.984	18.7	0.665	4.2
11kVField	0.984	18.7	0.665	4.2
11kVNorth	0.984	18.7	0.665	4.2
11kVSolar	0.984	18.7	0.665	4.2
11kVSouth	0.984	18.7	0.665	4.2
ADBSolar	1.103	21.0	0.618	3.9
Airport	0.949	18.1	0.459	2.9
Anabar	0.738	14.1	0.425	2.7
Arijejen	0.954	18.2	0.634	4.0
Civic	0.962	18.3	0.523	3.3
CommandRidge	0.984	18.8	0.645	4.1
DomSub	0.984	18.8	0.645	4.1
EUSolar	0.932	17.8	0.495	3.1
FreshCentre	0.931	17.7	0.387	2.5
FreshCentre_S1	0.851	16.2	0.476	3.0
FuelTankFarm	0.984	18.8	0.645	4.1
G10	0.000	0.0	0.000	0.0
G2	0.000	0.0	0.000	0.0
G2-1	0.000	0.0	0.000	0.0
G3	0.000	0.0	0.000	0.0
G3-1	0.000	0.0	0.000	0.0
G4	0.000	0.0	0.000	0.0
G5	0.000	0.0	0.000	0.0
G6	0.000	0.0	0.000	0.0
G7-8	0.000	0.0	0.000	0.0
Gon	0.946	18.0	0.446	2.8
Gonway	0.933	17.8	0.394	2.5
Ijew	0.715	13.6	0.386	2.5
Junct1	0.936	17.8	0.614	3.9
Junct2	0.904	17.2	0.580	3.7
Junct5	0.871	16.6	0.512	3.3
MFATSolar	1.103	21.0	0.618	3.9
Menen_E1	0.891	17.0	0.283	1.8
Menen_E1(1)	0.864	16.5	0.447	2.8
Menen_N1	0.645	12.3	0.334	2.1
Menen_S2	0.738	14.1	0.390	2.5
PS3.3kV-A	2.857	16.3	2.077	4.0
PS3.3kV-B	2.857	16.3	2.077	4.0
Pago	0.951	18.1	0.465	3.0
RPC1	1.090	20.8	0.616	3.9
RPC3RPC2Ronphos	0.972	18.5	0.527	3.3
RehabWorkshops	1.008	19.2	0.553	3.5
Ronave	0.777	14.8	0.461	2.9
Terrace	0.790	15.0	0.429	2.7
TheBay	0.671	12.8	0.353	2.2
UAESolar	0.893	17.0	0.554	3.5
Waboe	0.881	16.8	0.560	3.6

Table 35 Scenario 3 Maximum Short-Circuit Currents, BESS Fault contribution = 2.0 p.u., PV Fault contribution = 1.5 p.u. (NOP open, FF closed, EF closed)

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
11kVEast	1.713	32.6	1.764	11.2
11kVField	1.713	32.6	1.764	11.2
11kVNorth	1.713	32.6	1.764	11.2
11kVSolar	1.713	32.6	1.764	11.2
11kVSouth	1.713	32.6	1.764	11.2

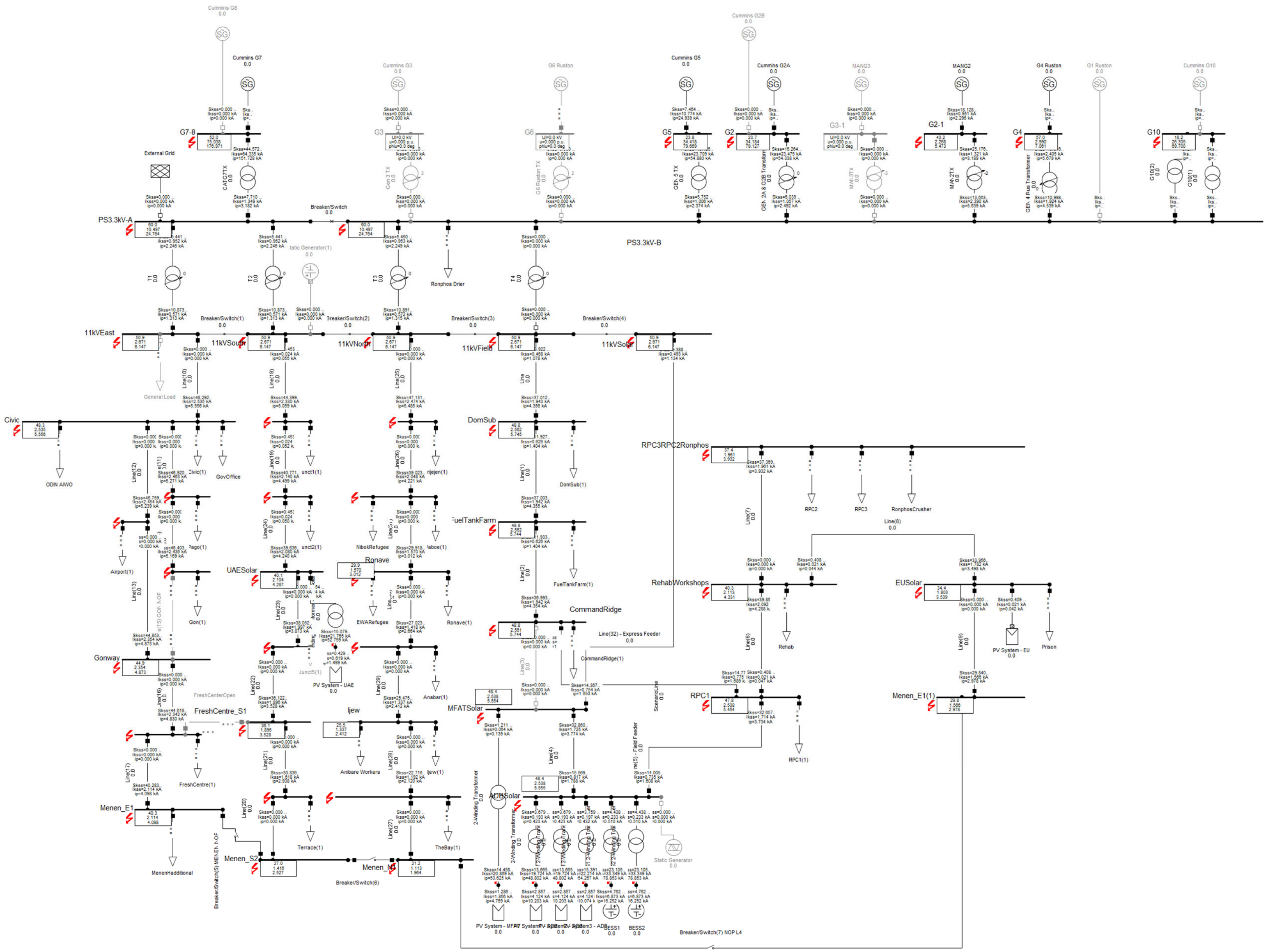
Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
ADBSolar	1.451	27.6	1.191	7.6
Airport	1.630	31.1	1.038	6.6
Anabar	1.110	21.2	0.724	4.6
Arijejen	1.634	31.1	1.558	9.9
Civic	1.661	31.7	1.294	8.2
CommandRidge	1.641	31.3	1.577	10.0
DomSub	1.641	31.3	1.577	10.0
EUSolar	1.186	22.6	0.810	5.1
FreshCentre	1.584	30.2	0.781	5.0
FreshCentre_S1	1.380	26.3	0.913	5.8
FuelTankFarm	1.641	31.3	1.577	10.0
G10	14.665	10.2	17.087	3.9
G2	31.454	21.8	36.465	8.4
G2-1	1.982	37.8	1.690	10.7
G3	0.000	0.0	0.000	0.0
G3-1	0.000	0.0	0.000	0.0
G4	2.249	42.8	1.613	10.2
G5	31.667	21.9	36.610	8.5
G6	0.000	0.0	0.000	0.0
G7-8	55.602	38.5	87.589	20.2
Gon	1.622	30.9	0.988	6.3
Gonway	1.589	30.3	0.805	5.1
Ijew	1.065	20.3	0.637	4.0
Junct1	1.581	30.1	1.438	9.1
Junct2	1.495	28.5	1.265	8.0
Junct5	1.425	27.1	1.026	6.5
MFATSolar	1.451	27.6	1.191	7.6
Menen_E1	1.487	28.3	0.486	3.1
Menen_E1(1)	1.082	20.6	0.694	4.4
Menen_N1	0.921	17.5	0.518	3.3
Menen_S2	1.114	21.2	0.657	4.2
PS3.3kV-A	7.726	44.2	11.199	21.3
PS3.3kV-B	7.726	44.2	11.199	21.3
Pago	1.633	31.1	1.062	6.7
RPC1	1.451	27.6	1.191	7.6
RPC3RPC2Ronphos	1.253	23.9	0.893	5.7
RehabWorkshops	1.311	25.0	0.972	6.2
Ronave	1.198	22.8	0.824	5.2
Terrace	1.231	23.5	0.762	4.8
TheBay	0.973	18.5	0.559	3.6
UAESolar	1.470	28.0	1.169	7.4
Waboe	1.445	27.5	1.176	7.5

Table 36 ***Scenario 5 Maximum Short-Circuit Currents, BESS Fault contribution = 2.0 p.u., PV Fault contribution = 1.5 p.u. (NOP open, FF closed, EF closed)***

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
11kVEast	2.671	50.9	2.059	13.1
11kVField	2.671	50.9	2.059	13.1
11kVNorth	2.671	50.9	2.059	13.1
11kVSolar	2.671	50.9	2.059	13.1
11kVSouth	2.671	50.9	2.059	13.1
ADBSolar	2.538	48.4	1.409	8.9
Airport	2.454	46.8	1.155	7.3
Anabar	1.418	27.0	0.795	5.1
Arijejen	2.474	47.1	1.795	11.4
Civic	2.535	48.3	1.467	9.3
CommandRidge	2.561	48.8	1.833	11.6
DomSub	2.562	48.8	1.833	11.6
EUSolar	1.803	34.4	0.924	5.9
FreshCentre	2.342	44.6	0.854	5.4

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
FreshCentre_S1	1.896	36.1	1.015	6.4
FuelTankFarm	2.562	48.8	1.833	11.6
G10	26.305	18.2	27.083	6.3
G2	34.184	23.7	38.457	8.9
G2-1	2.268	43.2	1.781	11.3
G3	0.000	0.0	0.000	0.0
G3-1	0.000	0.0	0.000	0.0
G4	2.990	57.0	1.750	11.1
G5	34.418	23.8	38.622	8.9
G6	0.000	0.0	0.000	0.0
G7-8	75.038	52.0	100.575	23.2
Gon	2.436	46.4	1.095	7.0
Gonway	2.354	44.9	0.880	5.6
Ijew	1.337	25.5	0.697	4.4
Junct1	2.354	44.8	1.646	10.5
Junct2	2.163	41.2	1.434	9.1
Junct5	1.997	38.1	1.148	7.3
MFATSolar	2.538	48.4	1.409	8.9
Menen_E1	2.114	40.3	0.522	3.3
Menen_E1(1)	1.566	29.8	0.784	5.0
Menen_N1	1.113	21.2	0.562	3.6
Menen_S2	1.416	27.0	0.719	4.6
PS3.3kV-A	10.497	60.0	12.827	24.4
PS3.3kV-B	10.497	60.0	12.827	24.4
Pago	2.463	46.9	1.183	7.5
RPC1	2.508	47.8	1.405	8.9
RPC3RPC2Ronphos	1.961	37.4	1.026	6.5
RehabWorkshops	2.113	40.3	1.124	7.1
Ronave	1.570	29.9	0.909	5.8
Terrace	1.618	30.8	0.840	5.3
TheBay	1.192	22.7	0.609	3.9
UAESolar	2.104	40.1	1.319	8.4
Waboe	2.048	39.0	1.325	8.4

Figure 2 ***Fault Level One Line Diagram for Scenario 5, BESS fault contribution = 2.0 p.u., Solar fault contribution = 1.5 p.u.***



C-2 Minimum Short-Circuit Analyses

Table 37 Scenario 2 - Minimum Short-Circuit Currents, BESS Fault contribution = 2.0 p.u., PV Fault contribution = 1.5 p.u. (NOP open, FF closed, EF closed)

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
11kVEast	0.868	16.5	0.288	1.8
11kVField	0.868	16.5	0.288	1.8
11kVNorth	0.868	16.5	0.288	1.8
11kVSolar	0.868	16.5	0.288	1.8
11kVSouth	0.868	16.5	0.288	1.8
ADBSolar	0.960	18.3	0.282	1.8
Airport	0.838	16.0	0.246	1.6
Anabar	0.655	12.5	0.243	1.5
Arijejen	0.843	16.1	0.283	1.8
Civic	0.850	16.2	0.261	1.7
CommandRidge	0.868	16.5	0.285	1.8
DomSub	0.868	16.5	0.285	1.8
EUSolar	0.820	15.6	0.260	1.6
FreshCentre	0.821	15.6	0.227	1.4
FreshCentre_S1	0.750	14.3	0.253	1.6
FuelTankFarm	0.868	16.5	0.285	1.8
G10	0.000	0.0	0.000	0.0
G2	0.000	0.0	0.000	0.0
G2-1	0.000	0.0	0.000	0.0
G3	0.000	0.0	0.000	0.0
G3-1	0.000	0.0	0.000	0.0
G4	0.000	0.0	0.000	0.0
G5	0.000	0.0	0.000	0.0
G6	0.000	0.0	0.000	0.0
G7-8	0.000	0.0	0.000	0.0
Gon	0.835	15.9	0.243	1.5
Gonway	0.823	15.7	0.229	1.5
Ijew	0.633	12.1	0.232	1.5
Junct1	0.828	15.8	0.280	1.8
Junct2	0.800	15.2	0.275	1.7
Junct5	0.769	14.7	0.261	1.7
MFATSolar	0.960	18.3	0.282	1.8
Menen_E1	0.785	15.0	0.192	1.2
Menen_E1(1)	0.761	14.5	0.249	1.6
Menen_N1	0.571	10.9	0.216	1.4
Menen_S2	0.651	12.4	0.232	1.5
PS3.3kV-A	2.549	14.6	0.952	1.8
PS3.3kV-B	2.549	14.6	0.952	1.8
Pago	0.839	16.0	0.248	1.6
RPC1	0.950	18.1	0.282	1.8
RPC3RPC2Ronphos	0.854	16.3	0.266	1.7
RehabWorkshops	0.884	16.8	0.271	1.7
Ronave	0.690	13.1	0.251	1.6
Terrace	0.697	13.3	0.242	1.5
TheBay	0.594	11.3	0.222	1.4
UAESolar	0.789	15.0	0.270	1.7
Waboe	0.780	14.9	0.271	1.7

Table 38 Scenario 4 - Minimum Short-Circuit Currents, BESS Fault contribution = 2.0 p.u., PV Fault contribution = 1.5 p.u. (NOP open, FF closed, EF closed)

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
11kVEast	0.870	16.6	1.106	7.0
11kVField	0.870	16.6	1.106	7.0
11kVNorth	0.870	16.6	1.106	7.0
11kVSolar	0.870	16.6	1.106	7.0
11kVSouth	0.870	16.6	1.106	7.0
ADBSolar	0.789	15.0	0.861	5.5
Airport	0.844	16.1	0.840	5.3
Anabar	0.663	12.6	0.602	3.8
Arijejen	0.846	16.1	1.026	6.5
Civic	0.854	16.3	0.953	6.1
CommandRidge	0.848	16.2	1.033	6.6
DomSub	0.849	16.2	1.034	6.6
EUSolar	0.694	13.2	0.655	4.2
FreshCentre	0.829	15.8	0.693	4.4
FreshCentre_S1	0.759	14.5	0.717	4.6
FuelTankFarm	0.849	16.2	1.034	6.6
G10	15.440	10.7	19.482	4.5
G2	22.083	15.3	28.857	6.7
G2-1	1.197	22.8	1.301	8.3
G3	0.000	0.0	0.000	0.0
G3-1	0.000	0.0	0.000	0.0
G4	0.000	0.0	0.000	0.0
G5	0.000	0.0	0.000	0.0
G6	0.000	0.0	0.000	0.0
G7-8	25.473	17.6	39.725	9.2
Gon	0.841	16.0	0.814	5.2
Gonway	0.830	15.8	0.708	4.5
Ijew	0.643	12.3	0.545	3.5
Junct1	0.830	15.8	0.976	6.2
Junct2	0.802	15.3	0.898	5.7
Junct5	0.776	14.8	0.780	5.0
MFATSolar	0.789	15.0	0.861	5.5
Menen_E1	0.796	15.2	0.474	3.0
Menen_E1(1)	0.651	12.4	0.582	3.7
Menen_N1	0.580	11.0	0.460	2.9
Menen_S2	0.660	12.6	0.557	3.5
PS3.3kV-A	3.345	19.1	4.872	9.3
PS3.3kV-B	3.345	19.1	4.872	9.3
Pago	0.845	16.1	0.852	5.4
RPC1	0.789	15.0	0.861	5.5
RPC3RPC2Ronphos	0.720	13.7	0.704	4.5
RehabWorkshops	0.742	14.1	0.748	4.8
Ronave	0.698	13.3	0.663	4.2
Terrace	0.706	13.5	0.626	4.0
TheBay	0.604	11.5	0.490	3.1
UAESolar	0.793	15.1	0.852	5.4
Waboe	0.786	15.0	0.856	5.4

Table 39 Scenario 5 - Minimum Short-Circuit Currents, BESS Fault contribution = 2.0 p.u., PV Fault contribution = 1.5 p.u. (NOP open, FF closed, EF closed)

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
11kVEast	2.522	48.0	2.057	13.1
11kVField	2.522	48.0	2.057	13.1
11kVNorth	2.522	48.0	2.057	13.1
11kVSolar	2.522	48.0	2.057	13.1
11kVSouth	2.522	48.0	2.057	13.1
ADBSolar	2.340	44.6	1.407	8.9
Airport	2.300	43.8	1.148	7.3

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
Anabar	1.303	24.8	0.789	5.0
Arijejen	2.331	44.4	1.792	11.4
Civic	2.384	45.4	1.461	9.3
CommandRidge	2.407	45.9	1.830	11.6
DomSub	2.407	45.9	1.831	11.6
EUSolar	1.654	31.5	0.919	5.8
FreshCentre	2.185	41.6	0.848	5.4
FreshCentre_S1	1.736	33.1	1.006	6.4
FuelTankFarm	2.407	45.9	1.831	11.6
G10	25.173	17.4	27.080	6.3
G2	33.026	22.9	38.453	8.9
G2-1	2.238	42.6	1.781	11.3
G3(5)	0.000	0.0	0.000	0.0
G3-1	0.000	0.0	0.000	0.0
G4	2.839	54.1	1.750	11.1
G5	33.215	23.0	38.617	8.9
G6	0.000	0.0	0.000	0.0
G7-8	75.707	52.5	100.504	23.2
Gon	2.281	43.5	1.088	6.9
Gonway	2.197	41.9	0.874	5.6
Ijew	1.211	23.1	0.689	4.4
Junct1	2.212	42.1	1.642	10.4
Junct2	2.025	38.6	1.429	9.1
Junct5	1.844	35.1	1.140	7.2
MFATSolar	2.340	44.6	1.407	8.9
Menen_E1	1.951	37.2	0.518	3.3
Menen_E1(1)	1.428	27.2	0.779	4.9
Menen_N1	0.993	18.9	0.556	3.5
Menen_S2	1.278	24.3	0.711	4.5
PS3.3kV-A	9.951	56.9	12.818	24.4
PS3.3kV-B	9.951	56.9	12.818	24.4
Pago	2.309	44.0	1.177	7.5
RPC1	2.316	44.1	1.403	8.9
RPC3RPC2Ronphos	1.808	34.5	1.021	6.5
RehabWorkshops	1.951	37.2	1.120	7.1
Ronave	1.451	27.6	0.902	5.7
Terrace	1.473	28.1	0.831	5.3
TheBay	1.070	20.4	0.602	3.8
UAESolar	1.960	37.3	1.312	8.3
Waboe	1.916	36.5	1.319	8.4

Table 40 ***Scenario 6 - Minimum Short-Circuit Currents, BESS Fault contribution = 2.0 p.u., PV Fault contribution = 1.5 p.u. (NOP open, FF closed, EF closed)***

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
11kVEast	0.361	6.9	0.277	1.8
11kVField	0.361	6.9	0.277	1.8
11kVNorth	0.361	6.9	0.277	1.8
11kVSolar	0.361	6.9	0.277	1.8
11kVSouth	0.361	6.9	0.277	1.8
ADBSolar	0.374	7.1	0.272	1.7
Airport	0.356	6.8	0.240	1.5
Anabar	0.322	6.1	0.238	1.5
Arijejen	0.358	6.8	0.273	1.7
Civic	0.358	6.8	0.253	1.6
CommandRidge	0.361	6.9	0.275	1.7
DomSub	0.361	6.9	0.275	1.7
EUSolar	0.352	6.7	0.252	1.6
FreshCentre	0.352	6.7	0.222	1.4
FreshCentre_S1	0.338	6.4	0.246	1.6
FuelTankFarm	0.361	6.9	0.275	1.7
G10	0.000	0.0	0.000	0.0
G2	0.000	0.0	0.000	0.0
G2-1	0.000	0.0	0.000	0.0
G3(5)	0.000	0.0	0.000	0.0
G3-1	0.000	0.0	0.000	0.0

Name	3 ph Ik" kA	3 ph Sk" MVA	1 ph Ik" A kA	1 ph Sk" A MVA
G4	0.000	0.0	0.000	0.0
G5	0.000	0.0	0.000	0.0
G6	0.000	0.0	0.000	0.0
G7-8	0.000	0.0	0.000	0.0
Gon	0.355	6.8	0.237	1.5
Gonway	0.353	6.7	0.224	1.4
Ijew	0.316	6.0	0.228	1.4
Junct1	0.355	6.8	0.270	1.7
Junct2	0.350	6.7	0.265	1.7
Junct5	0.342	6.5	0.253	1.6
MFATSolar	0.374	7.1	0.272	1.7
Menen_E1	0.345	6.6	0.191	1.2
Menen_E1(1)	0.341	6.5	0.243	1.5
Menen_N1	0.301	5.7	0.214	1.4
Menen_S2	0.318	6.1	0.228	1.4
PS3.3kV-A	1.159	6.6	0.916	1.7
PS3.3kV-B	1.159	6.6	0.916	1.7
Pago	0.356	6.8	0.241	1.5
RPC1	0.373	7.1	0.272	1.7
RPC3RPC2Ronphos	0.358	6.8	0.258	1.6
RehabWorkshops	0.363	6.9	0.262	1.7
Ronave	0.329	6.3	0.245	1.6
Terrace	0.327	6.2	0.237	1.5
TheBay	0.307	5.8	0.219	1.4
UAESolar	0.347	6.6	0.261	1.7
Waboe	0.347	6.6	0.262	1.7

Figure 3 Fault Level One Line Diagram for Scenario 1, BESS fault contribution = 2.0 p.u., Solar fault contribution = 1.5 p.u.

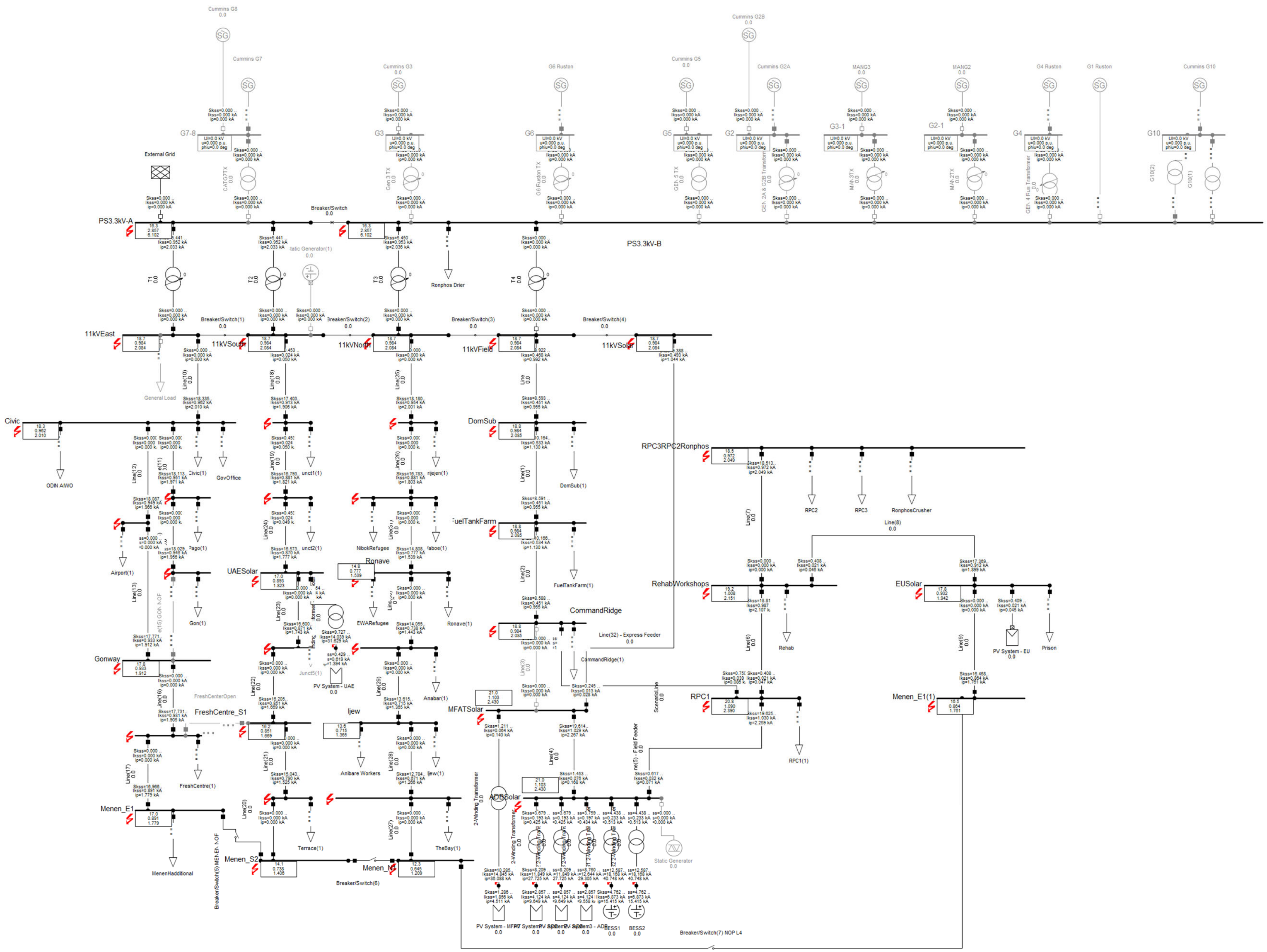
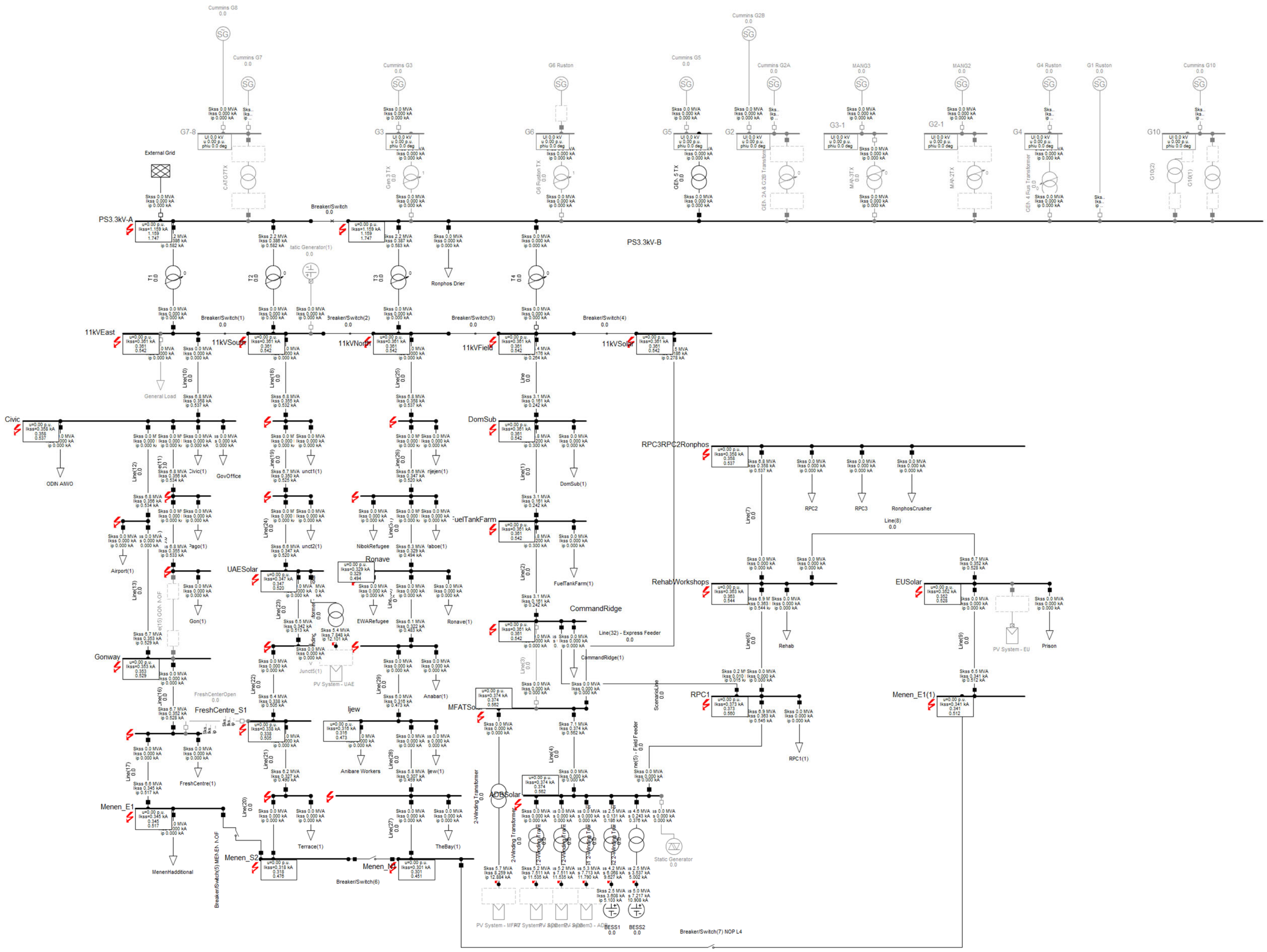
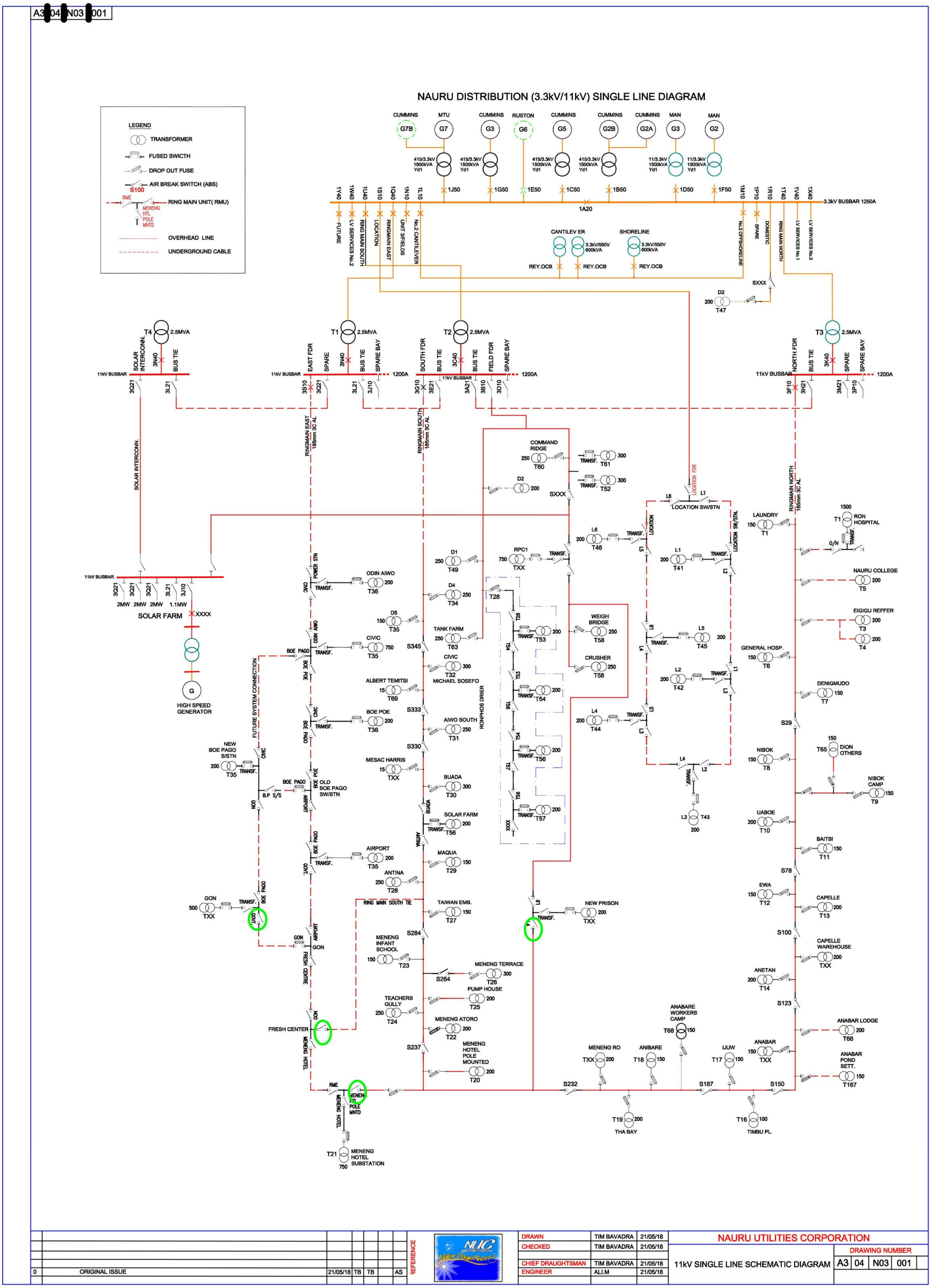


Figure 4 *Fault Level One Line Diagram for Scenario 6, BESS fault contribution = 2.0 p.u., Solar fault contribution = 1.5 p.u.*



Appendix D

NUC Network Configuration & Interconnection SLDs


NAURU DISTRIBUTION (3.3kV/11kV) SINGLE LINE DIAGRAM
LEGEND
TRANSFORMER
FUSED SWICTH
DROP OUT FUSE
AIR BREAK SWITCH (ABS)
RING MAIN UNIT(RMU)
OVERHEAD LINE
UNDERGROUND CABLE
3.3kV BUSBAR 1250A
11kV BUSBAR
SOLAR FARM
HIGH SPEED GENERATOR
CANTILEV ER
SHORELINE
NAURU UTILITIES CORPORATION
DRAWING NUMBER
A3 04 N03 001
11kV SINGLE LINE SCHEMATIC DIAGRAM
DRAWN TIM BAVADRA 21/05/18
CHECKED TIM BAVADRA 21/05/18
CHIEF DRAUGHTSMAN TIM BAVADRA 21/05/18
ENGINEER ALI.M 21/05/18
0 ORIGINAL ISSUE 21/05/18 TB TB AS
REFERENCE

Appendix E

Contractor's Response on Equipment Capability

September 3, 2024

To	CHEC	Contact No.	
Copy to	Claude Morris	Email	amit.datta@ghd.com
From	Amit Datta	Project No.	12543852
Project Name	NUC Solar PIC		
Subject	RFI #2 – Fault current contribution of PV/BESS inverters		

Model Clarifications

CHEC is requested to please confirm the following information:

1. CHEC to confirm fault current contribution of the PV inverters in accordance with section 6 – employer's requirements, clause 2.2.1.4.

   HNAC/2022.12.16: After confirm with the PV inverter OEM Ginlong Technology, the maximum fault current contribution of the S5-GC60K-HV inverter is 1.5 times of the rated output current, that is 1.5×79.4A=119.1A. If fault occurs, the inverter will send alarm signal to the monitoring/SCADA system and then shutdown within 100ms.

As per fault ride through and fault current requirement described in section 6 – employer's requirement-Clause 2.2.2.1.5, " the BESS shall have fault current ride through capability, be capable of providing a fault current contribution of no less than 2 p.u. for the pcs for at least 3 seconds for all balanced and unbalanced fault types with and without fault impedance." CHEC to provide datasheet to confirm compliance.

HNAC/2022.12.16:
After search the AS/NZS and IEC standards website or database, we have not found the related standard regarding the fault ride through capability of the power conversion system for battery storage system.
We think this requirement " the BESS shall have fault current ride through capability, be capable of providing a fault current contribution of no less than 2 p.u. for the pcs for at least 3 seconds for all balanced and unbalanced fault types with and without fault impedance." is very strict for a BESS system, if the PCS should provide 2 p.u fault current contribution for the PCS, the rated power capacity of the BESS PCS should be 2 times of the 5MW as the ERQ specified, that is should be 10MW, the battery charging and discharging rate also should be 4C rather than 2C(as implied by 5MW/2.5MWh), otherwise, the battery will be damaged by this extremely high discharging current rate.
According to the Chinese standard GB/T 34120-2017 Technical specification for power conversion system of electrochemical energy storage system, the Fault Ride Through capability requirements are shown as below for your reference.

ICS 27.180
F 19

中华人民共和国国家标准

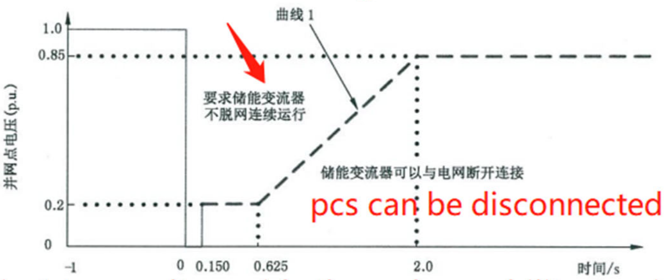
GB/T 34120—2017

电化学储能系统储能变流器技术规范

Technical specification for power conversion system of electrochemical energy storage system

PCS shall not disconnnected to the grid

Voltage at POC(p.u)



pcs can be disconnected to the grid

Fig 1 Low-voltage ride through capability requirements

注 1：对于三相短路故障和两相短路故障，考核电压为并网点线电压；对于单相接地短路故障，考核电压为并网点相电压。

注 2：对于并入 10(6)kV 以下电压等级电网的储能变流器，具备故障脱离功能即可。

Note2: for the PCS connected to the grid below 10(6)kV have fault disconnection capability is OK

图 1 储能变流器的低电压耐受能力要求

5.4.12.2 动态无功支撑能力

当电力系统发生短路故障引起电压跌落时，电化学储能系统储能变流器注入电网的动态无功电流应满足以下要求：

a) 自并网点电压跌落的时刻起，动态无功电流的响应时间应不大于 30 ms。

b) 自动态无功电流响应起直到电压恢复至 0.85(p.u.)期间，储能变流器注入电力系统的动态无功电流应实时跟踪并网点电压变化，并应满足：

$$I_T \geqslant 1.6 \times (0.85 - U_T) I_N \quad (0.2 \leqslant U_T \leqslant 0.85)$$

$$I_T \geqslant 1.04 \times I_N \quad (U_T < 0.2)$$

$$I_T = 0 \quad (U_T > 0.85)$$

式中：

U_T ——储能变流器并网点电压标幺值；

I_N ——储能变流器额定电流。

After confirm with the BESS PCS OEM Tianjin Electric Science Research Institute Co., Ltd, the maximum fault current contribution of the TPCS2-630-N32 BESS PCS is 1.5 times of the rated output current, that is 1.5×1000A=1500A within 10us, and 1.3×1000A=1200A within 2ms.

September 13, 2023

From: "Nauru Solar Farm - BESS Inverters Issues(Contractor responses 2023.09.13).pdf"

- BESS fault current contribution- what is the maximum fault current contribution that can be provided for ~1 second.
- **HNAC 2023.09.13**: The BESS inverter can meet the following requirements

Voltage of POC(U)	Voltage response capability
$U<50\%U_N$	Maximum tripping time not exceed 0.2s
$50\%U_N \leq U \leq 85\%U_N$	Maximum tripping time not exceed 0.2s
$85\%U_N \leq U<110\%U_N$	Continuous operating
$110\%U_N \leq U<120\%U_N$	Maximum tripping time not exceed 0.2s
$120\%U_N \leq U$	Maximum tripping time not exceed 0.2s
Note 1: U_N is the rated voltage of the Point of Connection (POC) Note 2: Maximum tripping time is the time between fault occurs and converter disconnected to the power grid.	

- (**Low-voltage ride through capability**) When a short-circuit fault occurs in the power system and causes a voltage drop, the dynamic reactive current injected into the power grid by the converter meets the following requirements:
  From the moment the voltage at the point of connection(POC) drops, the response time of dynamic reactive current will not be greater than 30ms.
  From the moment of dynamic reactive current response until the voltage recovers to 0.85P.U, the dynamic reactive current injected into the grid by the converter tracks the voltage changes at POC in real time and satisfies:

$$I_T \geqslant 1.6 \times (0.85 - U_T) I_N \quad (0.2 \leqslant U_T \leqslant 0.85)$$

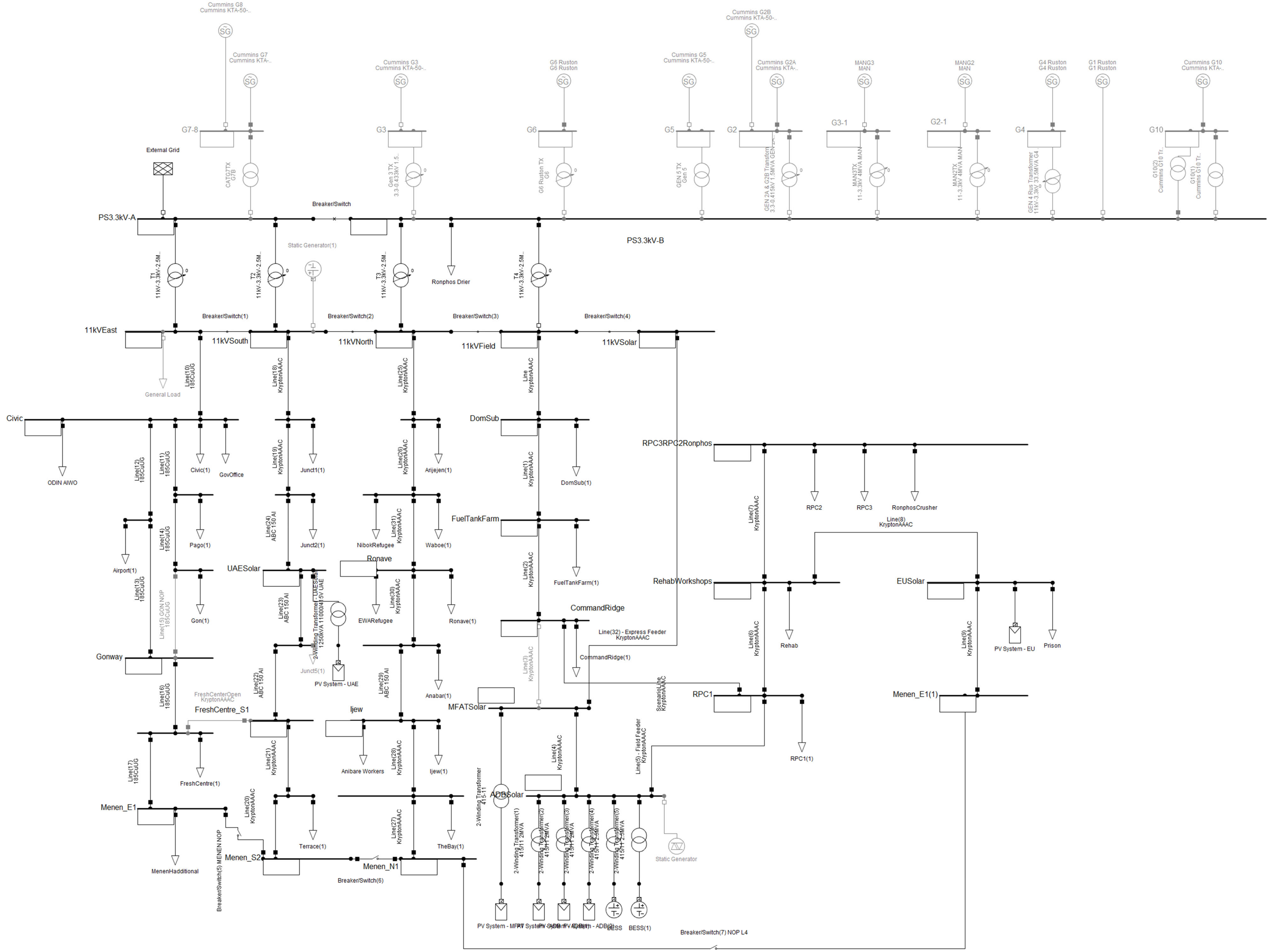
$$I_T \geqslant 1.04 \times I_N \quad (U_T < 0.2)$$

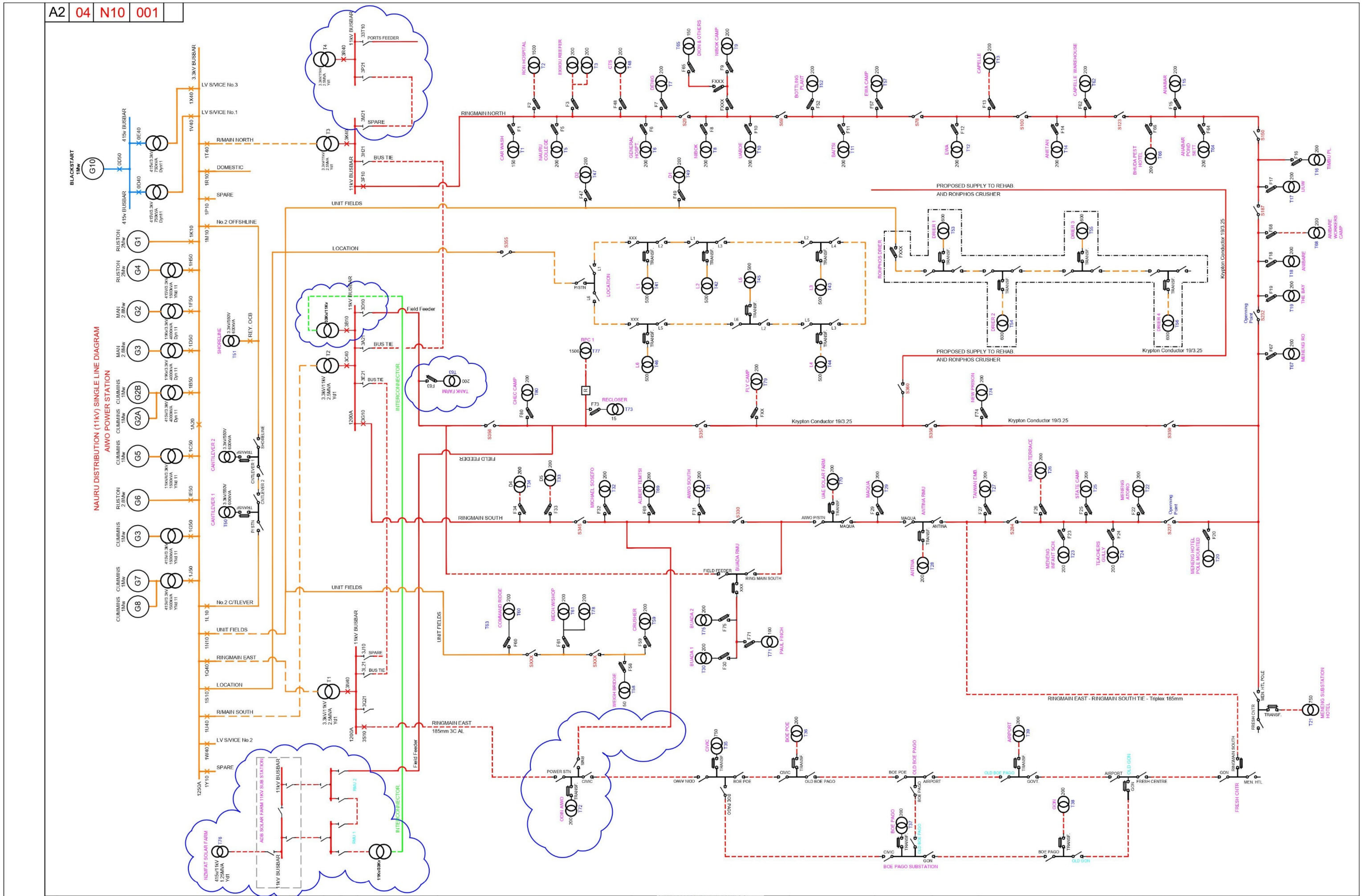
$$I_T = 0 \quad (U_T > 0.85)$$

Where: U_T- Per Unit Voltage of POC
I_T-Rated current of BESS inverter(A)

Appendix F

PV and BESS SLD


External Grid
PS3.3kV-A
PS3.3kV-B
Breaker/Switch
Ronphos Drier
11kVEast
11kVSouth
11kVNorth
11kVField
11kVSolar
Civic
DomSub
RPC3RPC2Ronphos
FuelTankFarm
UAESolar
Ronave
CommandRidge
RehabWorkshops
EUSolar
Gonway
MFATSolar
RPC1
Menen_E1(1)
FreshCentre_S1
Ijew
ADBSolar
Menen_E1
Menen_S2
Menen_N1
PV System - UAE
PV System - EU
BESS
BESS(1)
Breaker/Switch(7) NOP L4



No.	REVISION	DATE	BY	CHK	PSD	APP
4	REVISED ADDITION OF ADB SOLAR FARM SUB STATION	20/10/22	SB		JP	AA
3	REVISED ADDITION OF CHEC CAMP TRANSFORMER.	24/02/22	SB		ALI	CP
2	REVISED ADDITION OF ANTINA RMU, REMOVAL OF ABS 354, ADDITION OF FLY CAMP TRANSFORMER. Revision of Buada RMU	03/08/21	SB		ALI	CP
1	REVISED ADDITION OF BUADA RMU ETC.	25/11/20	TB		ALI	AS
0	ORIGINALISSUE	12/06/20	TB		ALI	AS

REFERENCE

DRAWING No.	TITLE
CAD FILENAME	NAURU DISTRIBUTION SLD

DRAWN	SEKOVE BARI	20/10/22
CHECKED	J. RODIBEN	20/10/22
CHIEF DRAUGHTSMAN		
ENGINEER	KEN BLAKE	20/10/22
HEAD OF DEPARTMENT	A. AREMWA	20/10/22

NAURU UTILITES CORPORATION

NAURU ELECTRICITY DISTRIBUTION
11Kv SINGLE LINE SCHEMATIC DIAGRAM
NAURU

DRAWING NUMBER: A2 | 04 | N10 | 001

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