Planning Report

EG and batteries under Chapter 5A
Site: Stuart Landfill Gas Generator

ACS Work Request: 1674326
Date Sent to customer: 11/11/2022
Version: 1.1

Part of Energy Queensland

Planning Report: Technical Assessment for Site STUART LANDFILL GAS GENERATOR

EXECUTIVE SUMMARY

Stuart Landfill Gas Generator was assessed to be a Class A1 system. There is sufficient power transfer capability available on the ST-02 Bruce Highway 11kV Feeder supplied from the Stuart 66/11kV (STUA) Substation in order to accommodate the proposed 1387 kVA EG system.

The system will be full export. It is proposed to operate in voltage control mode.

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1 INTRODUCTION

1.1 Overview

Ergon Energy Corporation Limited (***Ergon Energy*** or ***we***, ***our*** or ***us***) received a connection enquiry from LMS Energy Pty Ltd ABN 39059428474 (the ***Connection Applicant*** or ***you*** or ***your***) regarding the connection of a proposed new 1387 kVA reciprocating synchronous landfill gas *generating system* to *our distribution system* (the ***Project***) by July 2023.

This *Planning Report* forms the technical assessment for your proposed *generating system* and explores one option for connection.

From the preliminary information provided, it was determined that the Stuart Landfill Gas Generator is categorised as a Class A1 generating system under STNW1175. With a refinement in modelling, this categorisation can be confirmed.

1.2 Option 1: HV Connection via Tee-off from ST-02 11kV Feeder

This option provides *you* with a *connection* that involves establishing a new HV connection via a tee-off from the ST-02 11kV Feeder. The main work packages required to provide this *connection* are:

a) Recover Sub TVS2898 from pole 2076119;
b) Construct approx. 50m of new 11kV three-phase overhead line from pole 2076119 to a new pole inside the boundary of Lot 2 SP132603 using Iodine 7/4.75 AAAC conductor with a 60°C design temperature;
c) Install a new 11kV three-phase pole-mounted ACR with VT (NOJA OSM series) using the spur construction (with bypass arrangement) on the new pole inside the boundary of Lot 2 SP132603 (the ACR will be at the HV connection point); and
d) Recover all existing LV connections to Lot 2 SP132603[1].

The costs and implementation timing for this option shall be outlined in the Project Scope Statement.

2 OVERVIEW OF THE PROPOSED *PROJECT*

The *Connection Applicant* is proposing to install a 1387 kVA reciprocating synchronous landfill gas generator at the Stuart Landfill located approximately 10 km south-east of Townsville and 2.5 km east of *Ergon Energy's* Stuart 66/11kV (STUA) Substation (refer to locality map in Appendix A of the *Planning Report*).

The proposed 1387 kVA reciprocating synchronous landfill gas generator is proposed to operate in parallel with the distribution network, operating at full export up to 24 hours per day and 7 days a week throughout the year.

[1] As per Section 5.2 of the QECM, the distributor provides only one connection point to a customer's premises.

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3 EXISTING *DISTRIBUTION SYSTEM* IN THE AREA

3.1 General description of *distribution system*

The *premises* is located approximately 10 km south-east of Townsville and 2.5 km east of *our* Stuart 66/11kV (STUA) Substation. This is illustrated in Appendix A of this *Planning Report*. The nearest feeder is the ST-02 Bruce Highway 11kV Feeder, which is supplied from *our* Stuart 66/11kV (STUA) Substation. *Our* Stuart 66/11kV (STUA) Substation is supplied via the Townsville 66kV sub-transmission network.

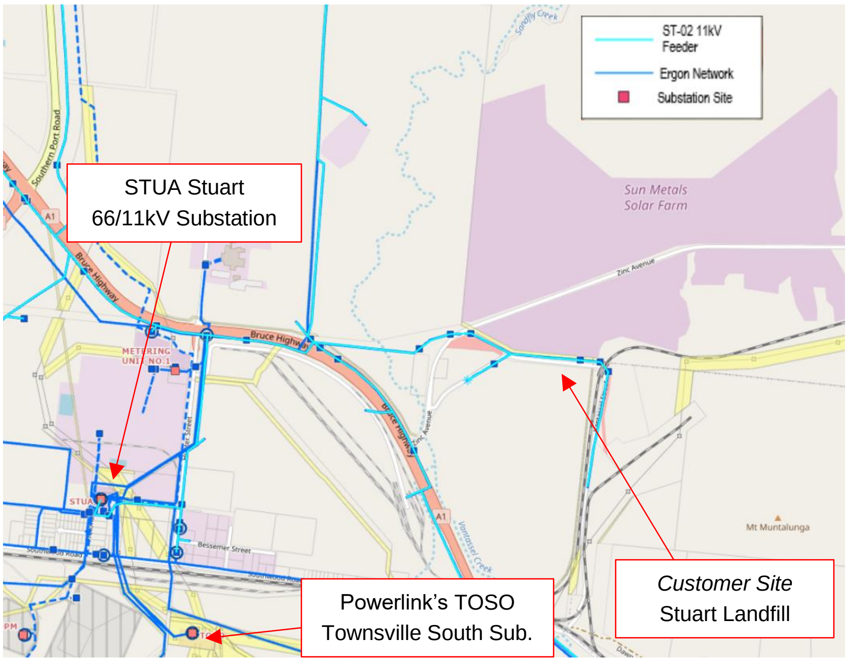

Figure 1 - Existing Network Configuration

3.2 Capacity of, and technical constraints on, relevant parts of the *distribution system* (and *transmission system*, if relevant)

Our Distribution Annual Planning Report [*DAPR*] *provides details of our distribution system*, system limitations for sub-transmission lines and zone substations and other information relevant to constraints on *our distribution system*. This information may be relevant to *your application to connect*.

The main items of plant and equipment that form part of *our distribution system* in the vicinity of *your* proposed *Project* which are relevant to *power transfer capability* are the Stuart 66/11kV (STUA) Substation and the ST-02 Bruce Highway 11kV Feeder.

Additional information about this plant and equipment can be found in the *Distribution Annual Planning Report (DAPR)*.

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Table 1– Primary Plant Nameplate Ratings

Substation	Plant	(MVA)[2]
Stuart 66/11kV (STUA) Substation	Transformer 1	21 MVA
	Transformer 2	21 MVA

Table 2– Feeder Capacity[3][4]

Feeder Name	ST-02 (Section 1)	ST-02 (Section 2)	ST-02 (Section 3)	ST-02 (Section 4)	ST-02 (Section 5)
Voltage (kV)	11 kV	11 kV	11 kV	11 kV	11 kV
Conductor Type	0.2in Cu PLY SWS	Pluto 19/3.75 AAC	Moon 7/4.75 AAC	240mm^2 Cu 3/c XLPE	Moon 7/4.75 AAC
Design Temp	-	75°C	50°C	-	50°C
Length (m)	161 m	1,400 m	1,350 m	110 m	600 m
Climate Zone	Eastern & Coastal	Eastern & Coastal	Eastern & Coastal	Eastern & Coastal	Eastern & Coastal
Summer Day A (MVA)	221 A (3.8 MVA)	551 A (9.4 MVA)	195 A (3.3 MVA)	415 A (7.1 MVA)	195 A (3.3 MVA)
Summer Evening A (MVA)	221 A (3.8 MVA)	582 A (10.0 MVA)	277 A (4.7 MVA)	415 A (7.1 MVA)	277 A (4.7 MVA)
Summer Night Morning A (MVA)	221 A (3.8 MVA)	524 A (9.0 MVA)	270 A (4.6 MVA)	415 A (7.1 MVA)	270 A (4.6 MVA)
Winter Day A (MVA)	221 A (3.8 MVA)	613 A (10.5 MVA)	285 A (4.9 MVA)	442 A (7.6 MVA)	285 A (4.9 MVA)
Winter Evening A (MVA)	221 A (3.8 MVA)	593 A (10.2 MVA)	317 A (5.4 MVA)	442 A (7.6 MVA)	317 A (5.4 MVA)
Winter Night Morning A (MVA)	221 A (3.8 MVA)	544 A (9.3 MVA)	291 A (5.0 MVA)	442 A (7.6 MVA)	291 A (5.0 MVA)
Feeder Bay / Protection Limitation	300 A (5.1 MVA)				

Please note that the information in the *Distribution Annual Planning Report (DAPR)* about capacity ratings of plant and equipment refers to the maximum possible ratings of the relevant equipment during normal operating conditions, assessed as at the date of the *DAPR*. Certain changes to system conditions can result in changes to actual ratings. An understanding of the maximum possible *power*

[2]The ONAN Rating of the transformers has been supplied. Studies on the effect of heavily loading transformers with generation output indicate this leads to an increase in the weighted average temperature of insulated paper windings. Generation connection and operation shall be restricted to the ONAN rating unless trip/curtailment schemes for the generator are in place to monitor operation of the cooling device.

[3] Feeder ratings are defined in Ampere (A). An MVA rating at 0.9pu volts has been supplied in order to ensure compliance with minimum voltage conditions.

[4] Where cable ratings are included, these will need to be reassessed using Cymcap studies for the changes to load factors during the technical assessment or detailed design phase.

transfer capability that could be available for the *Project* cannot be obtained without first carrying out appropriate *power system* studies.

3.3 Nearby generation and *power system stability* considerations

In addition, the following *generating systems* are either *connected* to *our distribution system* in the general vicinity of *your Project* or are committed and will be *connected* in the near future. These *generating systems* may also impact on the *power transfer capability* of *your* proposed *connection*:

a) Haughton Solar Farm 100MW
b) Clare Solar Farm 100MW
c) Daydream Solar Farm 150MW
d) Hamilton Solar Farm 57MW
e) Whitsunday Solar Farm 57MW
f) Hayman Solar Farm 50MW
g) Hughenden Solar Farm 18MW
h) Kennedy Energy Park 50MW
i) Kidston Solar Farm 50MW
j) Normanton Solar Farm 5MW
k) Ross River Solar Farm 135MW
l) Sun Metals Solar Farm 125MW
m) Mt Stuart GT Power Station 423MW
n) Townsville (Yabulu) GT Power Station 242MW
o) Barron Gorge Hydro Power Station 60MW
p) Tully Sugar Mill 21MW
q) Victoria Sugar Mill 24MW
r) Macknade Sugar Mill 8MW
s) Invicta Sugar Mill 34MVA
t) Pioneer Sugar Mill 84.8MVA
u) Kalamia Sugar Mill 11.3MVA
v) Inkerman Sugar Mill 16.1MVA
w) Micro Embedded Generation Units.

3.3.1 Micro Embedded Generation Forecast

Ergon Energy classifies generating units having a capability of less than 10kVA for a single phase connection or 30kVA for a three phase connection as Micro Embedded Generation Units (MEGU). This may have long-term impact on the available *capacity* in the network.

The capacity of embedded generation within Ergon Energy's network is continuing to increase. The MEGU forecast for the Stuart 66/11kV (STUA) Substation and the ST-02 Bruce Highway 11kV Feeder is provided below.

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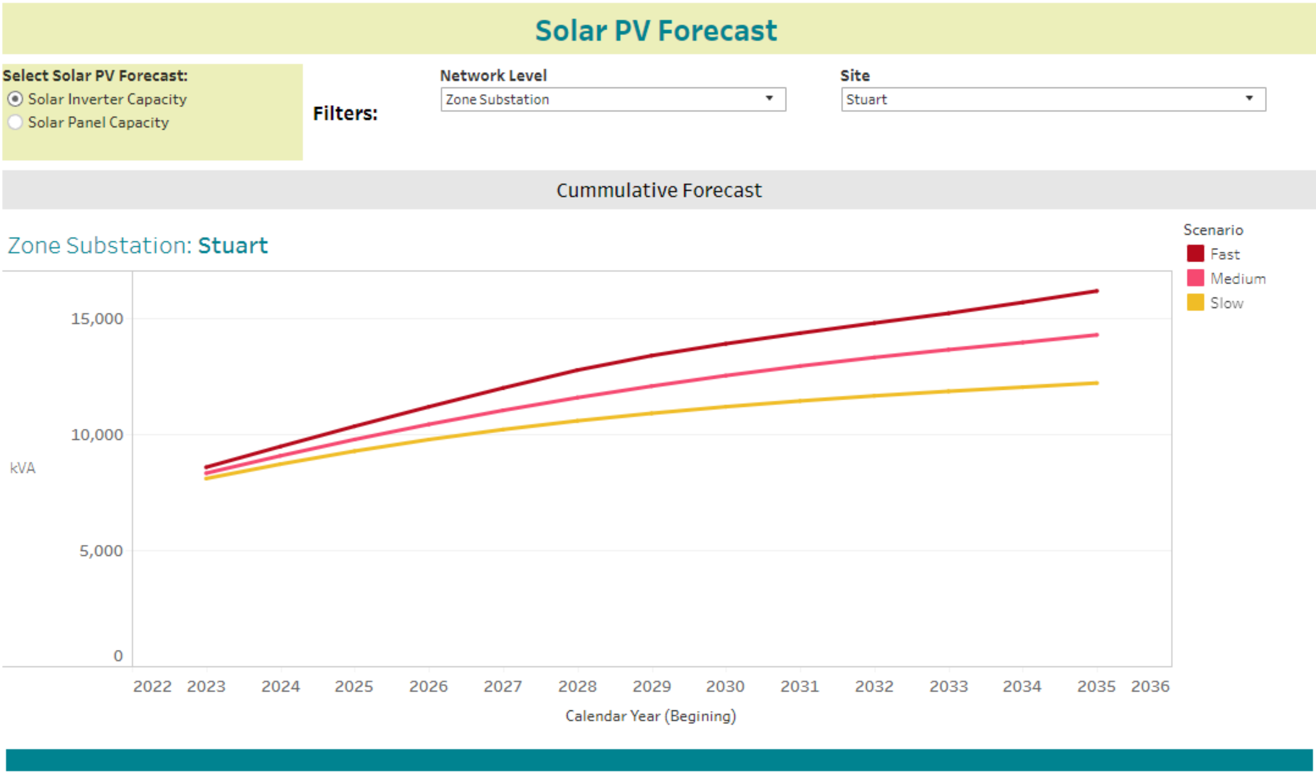

Figure 2 – Stuart Substation MEGU Forecast

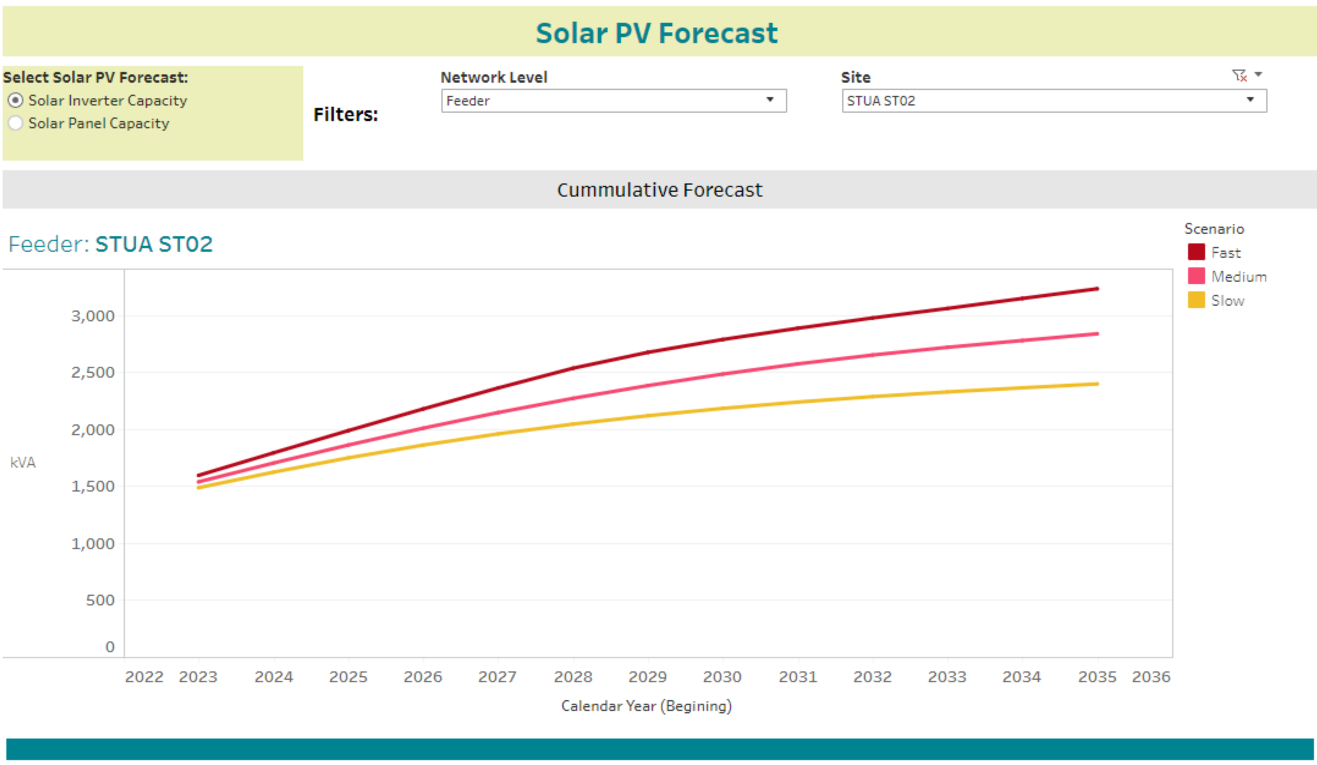

Figure 3 – ST-02 Feeder MEGU Forecast

The actual scenario is the same in all cases. The general assumptions are:

- Retail electricity prices follow trends of AEMO forecasts
- Solar prices continue to decline at current trends
- Feed in tariffs stay constant
- There are no government incentives
- The level of uptake will slow down as penetration of PV reaches a saturation point

3.4 Historical Load Profile

The minimum demand forecast for the Stuart 66/11kV (STUA) Substation and the ST-02 Bruce Highway 11kV Feeder is provided below.

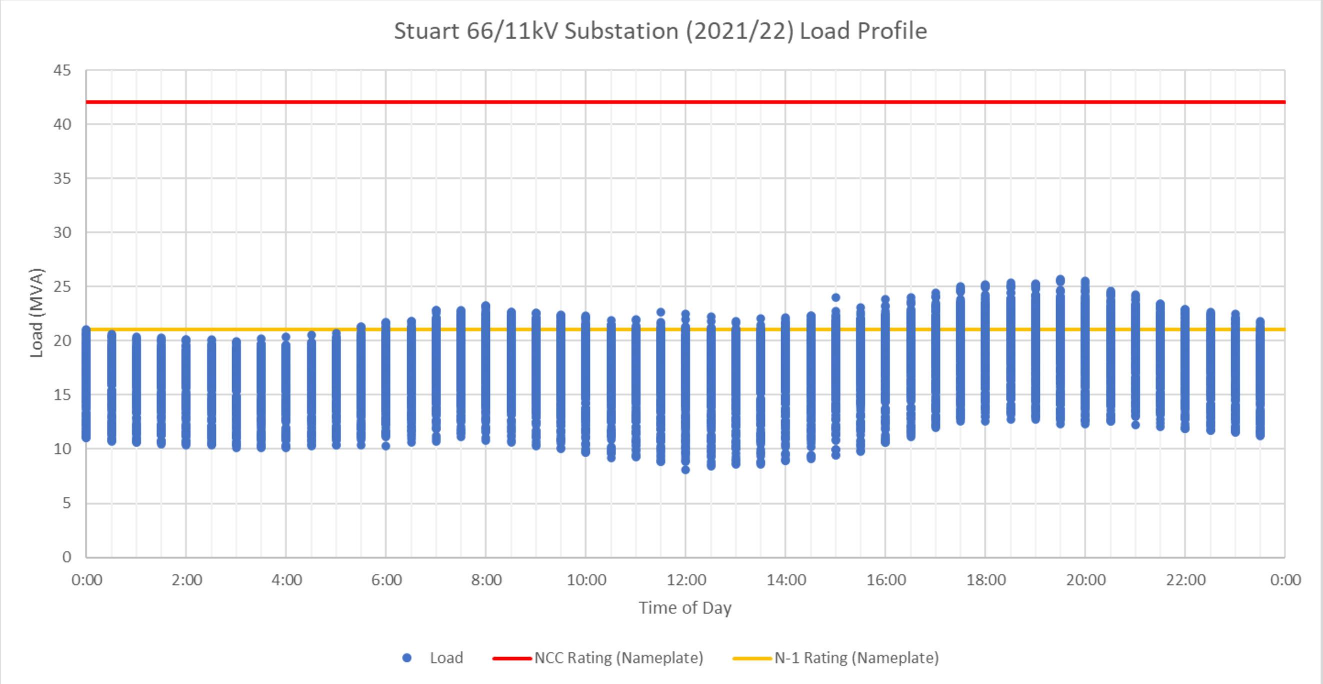

Figure 4 – Stuart Substation Load Profile

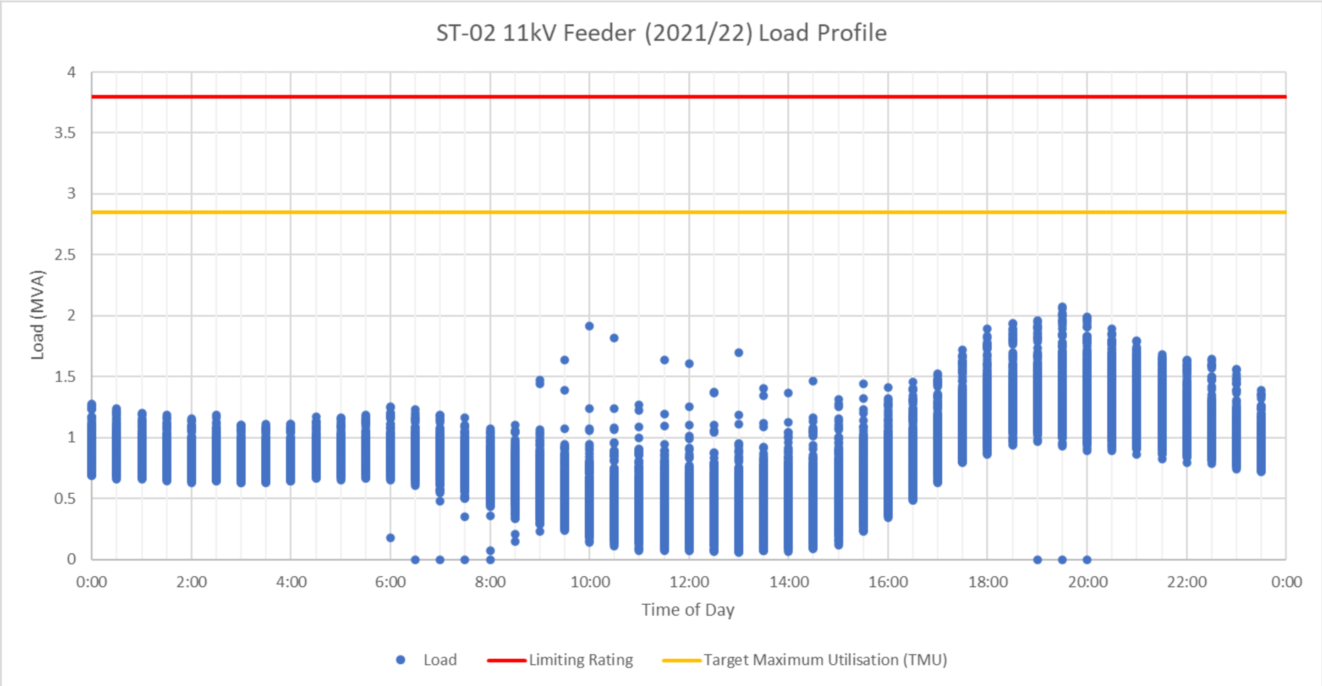

Figure 5 – ST-02 Feeder Load Profile

3.5 Minimum Demand Forecast

The minimum demand forecast for the Stuart 66/11kV (STUA) Substation and the ST-02 Bruce Highway 11kV Feeder is provided below.

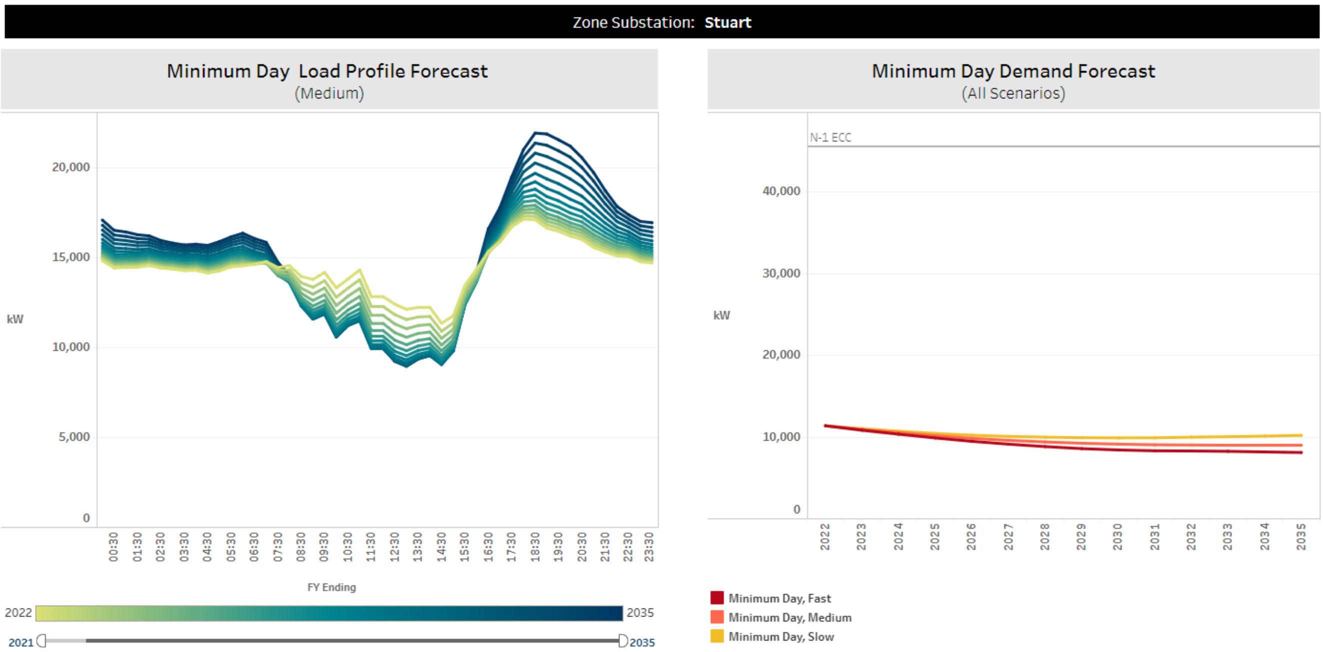

Figure 6 – Stuart Substation Minimum Demand Forecast

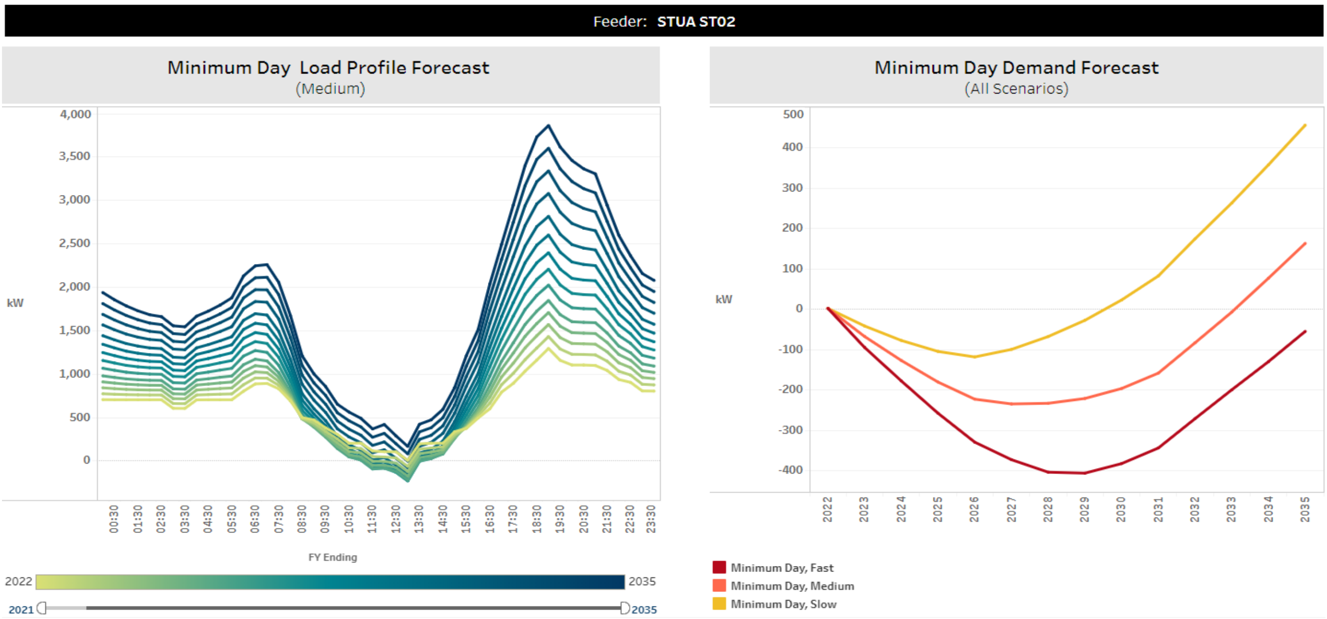

Figure 7 – ST-02 Feeder Minimum Demand Forecast

3.6 Maximum Demand Forecast

The 50POE[5] maximum demand forecast for the Stuart 66/11kV (STUA) Substation and the ST-02 Bruce Highway 11kV Feeder is provided below.

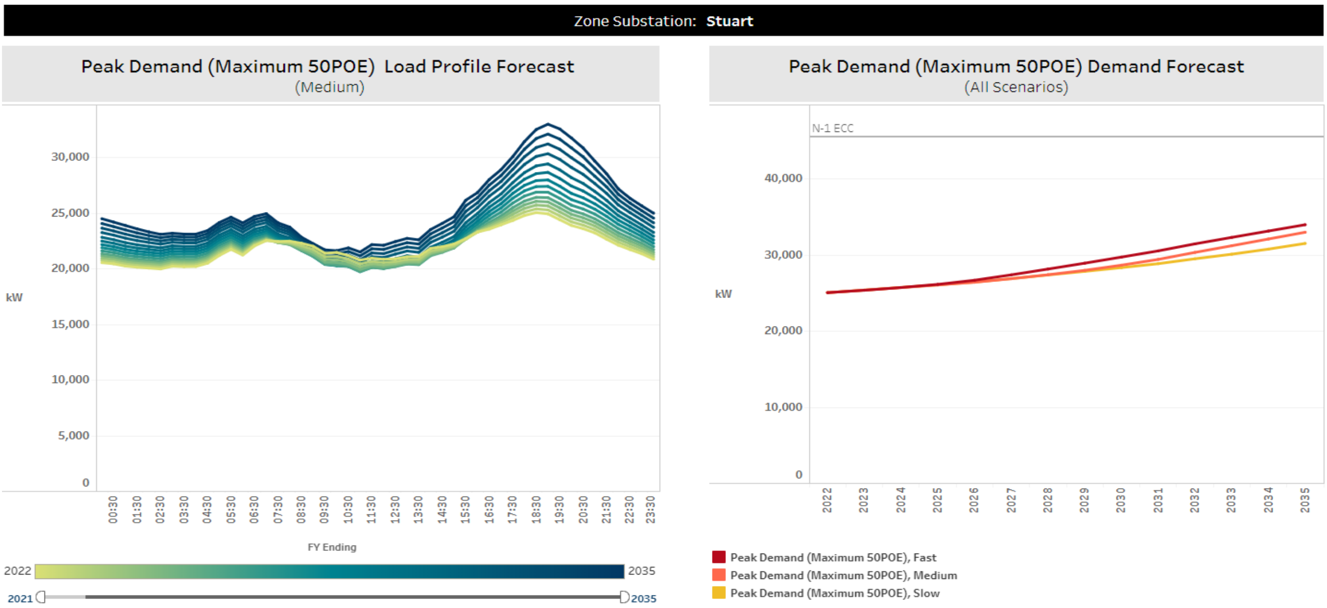

Figure 8 – Stuart Substation Maximum Demand Forecast

[5] POE- probability of exceedance. A 50% POE MD value is expected to be exceeded, on average, one year in two.

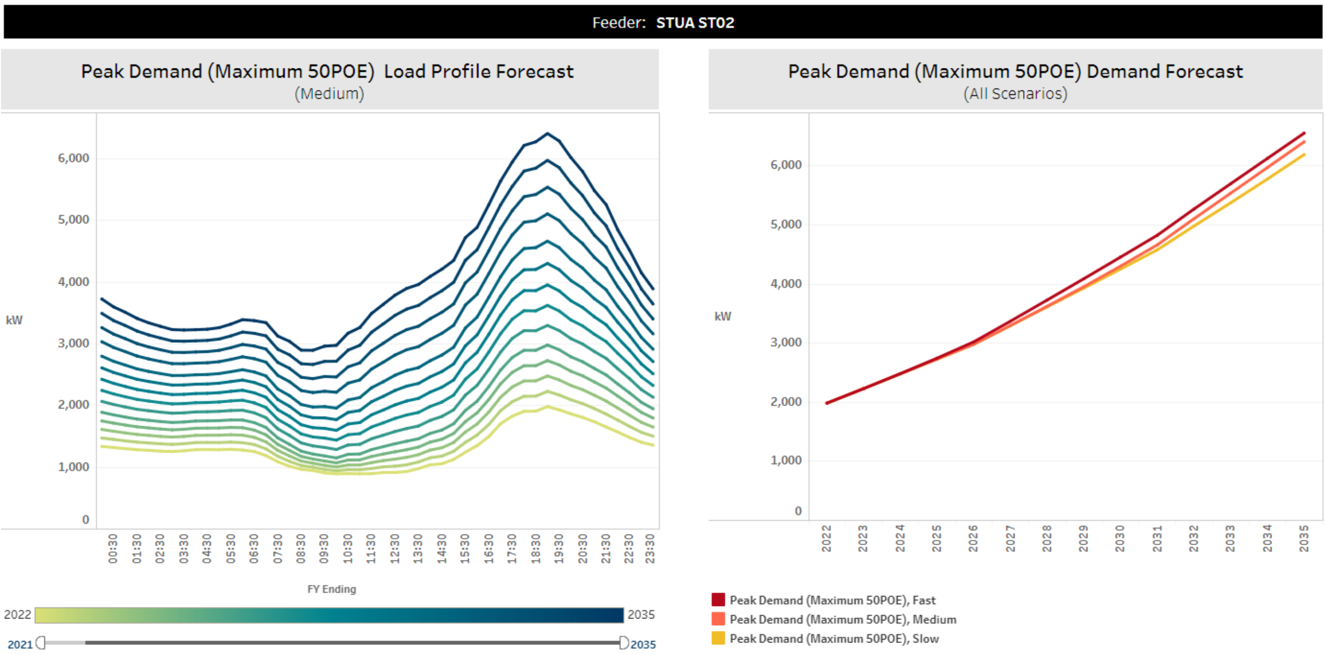

Figure 9 – ST-02 Feeder Maximum Demand Forecast

4 SCOPE OF WORKS REQUIRED

4.1 Overview of *connection* option

This *connection* option, which is illustrated in Item **12.1** of Appendix B, involves providing a connection via a HV tee-off from the ST-02 Bruce Highway 11kV Feeder.

4.2 Connection point, network coupling point and metering point

It is proposed that:

a) the *connection point* is located at the customer side 11kV terminals of the new Automatic Circuit Recloser (ACR);

b) the *network coupling point* is located at pole 2076119; and

c) the *metering point* is located on the customer side of the connection point (as close to the connection point as possible);

4.3 Augmentation requirements

The existing ST-02 Bruce Highway 11kV Feeder has sufficient available capacity to supply the requested load for the LMS Energy Pty Ltd Stuart Landfill Gas Generator without augmentation.

4.4 Options for construction of dedicated assets

The design and construction of dedicated assets used to connect a *Connection Applicant's* facility to *our distribution system* is an *alternative control service* (ACS). This work is fully funded upfront by the *Connection Applicant*.

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Subject to certain exceptions, *you* have three options for the design and construction of these assets, being:

a) *you* design, build and own the infrastructure;

b) *we* design, build and own the infrastructure; or

c) *you* design and build the infrastructure and then gift this to *us*.

Note that *we* will not accept ownership of any assets which are not to *our* standards or of a standard type. Further information on *our* requirements in relation to this can be supplied upon request.

Note that not all of the above options may be viable due to unacceptable risks that these options may pose to *us* in certain instances. For example, *we* would normally be responsible for designing, building and owning assets within *our* substations, even if these assets are dedicated assets.

The other work that enables *your* facility to connect to *our distribution system* related to shared assets. The provision of these assets is a *standard control service* (SCS), the cost of which is recovered from *our* relevant customers through ongoing network charges. All such shared assets will continue to be built, maintained and owned by *us*.

4.5 Scope of Ergon Energy works

The *Ergon Energy* works that need to be done to facilitate this option essentially comprise the following:

a) Recover Sub TVS2898 from pole 2076119;

b) Construct approx. 50m of new 11kV three-phase overhead line from pole 2076119 to a new pole inside the boundary of Lot 2 SP132603 using Iodine 7/4.75 AAAC conductor with a 60°C design temperature;

c) Install a new 11kV three-phase pole-mounted ACR with VT (NOJA OSM series) using the spur construction (with bypass arrangement) on the new pole inside the boundary of Lot 2 SP132603 (the ACR will be at the HV connection point); and

d) Recover all existing LV connections to Lot 2 SP132603[6].

The costs and implementation timing for this option shall be outlined in the Project Scope Statement.

4.6 Scope of Connection Applicant works

The *Connection Applicant* works that need to be done to facilitate this option essentially comprise the following:

a) Complete all works beyond the connection point;

b) Provision of any digital or analogue data required for protection and operational purposes for the Ergon Energy protection and SCADA systems;

c) Implement necessary protection schemes as required under STNW1175;

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[6] As per Section 5.2 of the QECM, the distributor provides only one connection point to a customer's premises.

d) Installation of suitable loss of mains protection equipment and synchronising equipment - the *Connection Applicant* would need to install suitable loss of mains protection to ensure that the generator is disconnected from the network during a network outage. The *Connection Applicant* would require synchronising and synchronising check facilities at the Generator's circuit breaker that interfaces with the network and wherever else they may choose to synchronise. These facilities would need to include a dead bus check system preventing the customer closing the generator onto the network when it is de-energised; and

e) Testing and commissioning of any cross-boundary protection, control and communications systems jointly with Ergon Energy.

4.7 Contestable works

a) Install a revenue metering system at the new connection point according to the requirements outlined in Chapter 7 of the National Electricity Rules

5 OPERATING PROTOCOL

An operating protocol will be required between *Ergon Energy* and *LMS Energy Pty Ltd* to facilitate the operational requirements of both parties.

The operating protocol will include, but not be limited to, the following information / considerations:

a) Switching and access to the Connection Point

b) Training and authorisation

c) First call response and communications details

d) Operating information and operational issues

e) Outage coordination.

6 TECHNICAL REQUIREMENTS

6.1 Adherence to Standards

It is requirement that the generating system adheres to the requirements of STWN1175, available on the Ergon Energy Website Generation Information Page.

An assessment of the *generating system* has been made with respect to the STWN1175 Connection classes. The *generating system* has been assessed as Class A1.

6.2 Access Standards

The Stuart Landfill Gas Generator will need to comply with the performance requirements set out in Table 3 below in order to connect to the Ergon Energy network. Documentation detailing the levels to which the system will respond for each clause identified is required. The generator will be required to undertake commissioning tests to demonstrate adherence to Table 3. These access standards are considered engineering best practice and will enable acceptable power quality for all network users. A template *Non-Registered Performance Standard* will be provided to *you.* A high-level summary of expected performance standards is provided below, however for completeness and comprehensiveness, the template *NRPS* should be reviewed:

Table 3 - Nominated Access Standards

Description	Access Standard	NER Schedule 5.2 Equivalent
Reactive Power Capability	1.11 MW, 0.44 MVAr capability Transformer details may need to be included to determine the reactive contribution of the generator	S5.2.5.1
Quality of electricity generated	Harmonic and flicker allocation detailed in Section 8.7 Harmonic and Flicker Allocation below	S5.2.5.2
Generating response to disturbances	Fault ride-through functionality of the plant must be enabled; it is expected that the generator can tolerate voltage, frequency and power quality disturbances	S.5.2.5.3, S5.2.5.4, S5.2.5.5, S5.2.5.6
Protection systems that impact on power system security	Protection system designed so as to not cause a material impact on power system security or power quality to other users	S5.2.5.8, S5.2.5.9
Protection to trip plant for unstable operation	Protection to trip plant for unstable operation, such as pole-slip for rotating machines, or emission of unstable voltage, reactive power or active power.	S5.2.5.10
Frequency control	Respond to system frequency events	S5.2.5.11
Voltage and reactive power control	0.98 pu with 4% droop on MVA base of 1.387MVA. Multiple operation modes not required.	S5.2.5.13
Active power control	Respond to active power signalling as defined by the curtailment scheme(s) – where applicable	S5.2.5.14
Remote monitoring and control	As required by Class A1 in STNW1175	S5.2.6.1 and 4.11.1
Fault current	To verify impact on the network by the generating fault currents	S5.2.8

6.3 Voltage level

In accordance with 5.3.3 (b1) (7), of the *NER*, *you* are advised as follows:

Normal voltage level	The *normal voltage* or *standard voltage* level will be the same as the *nominal voltage* level of 11kV. The expected voltage range will be 11kV +/-5% as legislated in the *Queensland Electricity Regulation*.

6.4 Voltage/power factor control

The proposed *generating system* must control the voltage to within 0.5% of its set-point at the *point of connection*, unless this is not practicable. This will ensure that the *Project* possesses adequate *reactive power* capability to ensure that the *voltage* at the *connection point* is kept within a specified *voltage* set-point determined by *us*.

The parties will need to develop and agree upon a *voltage* control strategy document. A draft *voltage control strategy* shall be submitted as part of the *application to connect*.

It is proposed that the generating system will operate in voltage control mode, utilising 4% droop, controlling the 11kV connection point to a set-point of 0.98p.u. Additional studies may be required to determine the optimal operating level. It must also be noted that network changes occur from time-to-time and the set-point may be adjusted as required to ensure Ergon Energy meets voltage compliance with respect to the National Electricity Rules (NER) (refer: https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules), or to ensure an optimal operating envelope.

Where the voltage control scheme relies on communications between items of plant, for example, a power quality analyser and the power plant controller, a communication-failure response shall be developed by the proponent to ensure a failure mode acceptable to all parties. This will be tested during commissioning.

6.5 Anti-islanding provisions

Under no circumstances should the *generating system* be permitted to form an island with part of *our distribution system*, unless prior written specific authorisation is obtained from *us*.

6.6 Break-Before-Make Generators

Where a facility includes break-before-make generating units, these will not be included in the aggregation of generation systems to determine system classification. Information on connection topology, e.g., schematics showing keyed switching, may be required to confirm the arrangement.

6.7 Integrating Energy Storage Systems Rule Change

Proponents should be aware of upcoming changes to the National Electricity Rules, set out in ERC0280 on the AEMC website (https://www.aemc.gov.au/rule-changes/integrating-energy-storage-systems-nem). These changes are intended to apply to storage systems, hybrid systems (for example, a facility comprising of wind and solar generation), and sites with generation and load. This rule changes clarifies requirements around registration, market participation and performance standards and will come into effect from the 3rd of June 2024, with some changes for hybrid and small generator aggregators coming into effect by the 31st of March 2023. Proponents are encouraged to review these changes to determine how this may affect their project.

7 POTENTIAL PROJECT CONSTRAINTS AND RISKS

7.1 Equipment Ratings

In some cases, equipment ratings (for example, of overhead lines) require verification. This may introduce delays during the project phases as the appropriate checks are undertaken. If line ratings are not sufficient for a connecting load's requirements, line uprating works will form part of the scope of works required for connection.

7.2 *Voltage* impacts of transformer(s) energisation

The *connection* of *load* often involves the establishment of new *transformers*. However, the energisation of *transformers* can result in unacceptable *voltage* fluctuations (particularly dips) being experienced on the *distribution system*. Various mechanisms can be implemented to avoid these *voltage* impacts, such as:

a) reducing the capacity of the *transformer(s)*;

b) installing appropriate switching plant such as circuit breakers compatible with point-on-wave switching; and

c) restricting the energisation of the *transformer* during certain operational scenarios.

Ergon Energy requires that voltage fluctuations caused by transformer energisation is within the limits defined in the Plant Energisation Standard (STNW1179), available on *our* website.

7.3 Installation / Commissioning

Construction of the proposed connection assets may require outages to the 11kV feeder supplying other customers. Depending on the length and frequency of these outages, additional costs may be incurred to maintain continuity of supply for other customers.

7.4 Additional Protection Works

Protection equipment in addition to that identified in the scope of works may be required to ensure the connection is able to meet the requirements of STNW1175. The introduction of this generator may desensitise existing distribution protection systems on the ST-02 Bruce Highway 11kV Feeder to such a degree that additional protection equipment is required.

This will be confirmed following the protection review as part of the Technical Assessment.

7.5 Future Load Changes

Load changes in the Stuart distribution area may introduce future constraints on the export capability due to loading and voltage management considerations.

7.6 AEMO Generator Exemption

The proponent must be aware of the registration requirements which may apply to their system. A standing exemption does not apply where the nameplate (e.g. inverter capacity at 25°C ambient temperature) exceeds 5MW. As the proponent has proposed <5MW of generation capacity, this is not likely to be a risk.

Refer to the AEMO generator exemption and classification guide for more information:
https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/New-participants/Exemption-and-classification-guides

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8 POWER SYSTEM MODELLING

The PowerFactory modelling software tool was used to model the steady state impacts of the *connection* of the proposed *generating system* on *our distribution system*.

8.1 Modelling Assumptions

The following key assumptions have been used when modelling the impacts of the proposed Stuart Landfill Gas Generator on the *Ergon Energy* network:

- Impedance detail of lines in modelling software is representative of actual line impedances.
- Line details in Ergon Energy's GIS and transformer impedance information are correct.
- Primary plant configuration is as per the requirements for connection listed in this report.
- Modelling to assess the impact of the *generator* was performed based on historical measured load data from 01/07/2021 to 01/07/2022. This is expected to be indicative of a "normal" year. However it should be considered as a sample and may not consider all network conditions or may include abnormal network conditions.
- Reactive power capability limits are based on clause S5.2.5.1 which dictates that 0.395 of the nameplate P rating of the plant is required to be available under the automatic access standard. It is recognised that S5.2.5.1 does not strictly apply to generators under the Chapter 5A connection process but serves as a suitable technical benchmark for reactive power capability for planning purposes as discussed in STNW1175.

8.2 Steady state load flows – Option 1: HV Connection via ST-02

The steady state load flow studies were conducted to investigate the distribution system to analyse the impact of the proposed *generating system* on network voltages and plant ratings.

Generator rejection studies were also completed to investigate the voltage fluctuation following generator disconnection at the *connection point*.

The following methodologies apply:

- A PowerFactory model was derived from the Ergon Energy Townsville Distribution Network Master Model and the Sub-transmission Network Master Model.
- The boundaries of the model used were the 66kV bus at Stuart Substation.
- The Ergon owned power transformers have been set with controllers for voltage limits corresponding to existing set point information. The current settings applicable to Transformer 1 and 2 at Stuart Substation include a voltage setpoint of 0.98pu. Each transformer has its individual voltage setpoint active power target settings, and when operating in parallel (system normal) the target values of power are summated with one transformer being a master and the other a follower.
- 11 kV ST-02 feeder supplies the Stuart Landfill site, all other 11kV feeders have been modelled as lumped loads at the 11kV bus of STUA.
- To model the loads on the 11kV ST-02 feeder, the loading data for ST-02 over the specified time period have been used to apply proportional loading profiles to each 11kV distribution transformer.
- Quasi-dynamic tests were conducted to benchmark model performance against historical data.

- For the purpose of the quasi-dynamic load flow analysis, the power factory model includes a synchronous generator element which represents the total capacity of the Stuart Landfill Gas generating system throughout the various scenarios.
- Analysis was performed on the following scenarios:
  - Scenario 1 (Base Case) - 11kV bus at STUA run normally closed with the total STUA load being supplied from the 66kV sub-transmission source. During the base case the proposed new generating system is not in service.
  - Scenario 2 - The proposed case where the Stuart Landfill Gas Generator is exporting their full requested export of 1.11 MW and operating in voltage control mode, utilising 4% droop, controlling the 11kV connection point to a set-point of 0.98p.u.
- A quasi-dynamic load flow and generator rejection analysis was then performed. This modelling methodology effectively performed a load flow for each half hour period between the specified dates.
- Relevant data was then exported and analysed, which is detailed in the following sections of the report

8.2.1 Scenario 1 – Base Case (Generator Not in Service)

This scenario involved investigating the operating state of the system in its existing state without the proposed new generator in service.

8.2.1.1 System Voltages

Figure 10 presents the range of voltages at each key system node, the 11kV bus voltage at Stuart 66/11kV (STUA) Substation is being regulated between 0.97 p.u. – 0.993 p.u. The proposed generator connection point has a modelled voltage range of 0.965 p.u. – 0.991 p.u. with an average voltage of 0.978 p.u.

The steady state voltage for the other customers on the ST-02 11kV feeder is able to be maintained within the allowable voltage range of 230V +10%/ 6% as legislated in the *Queensland Electricity Regulation*.

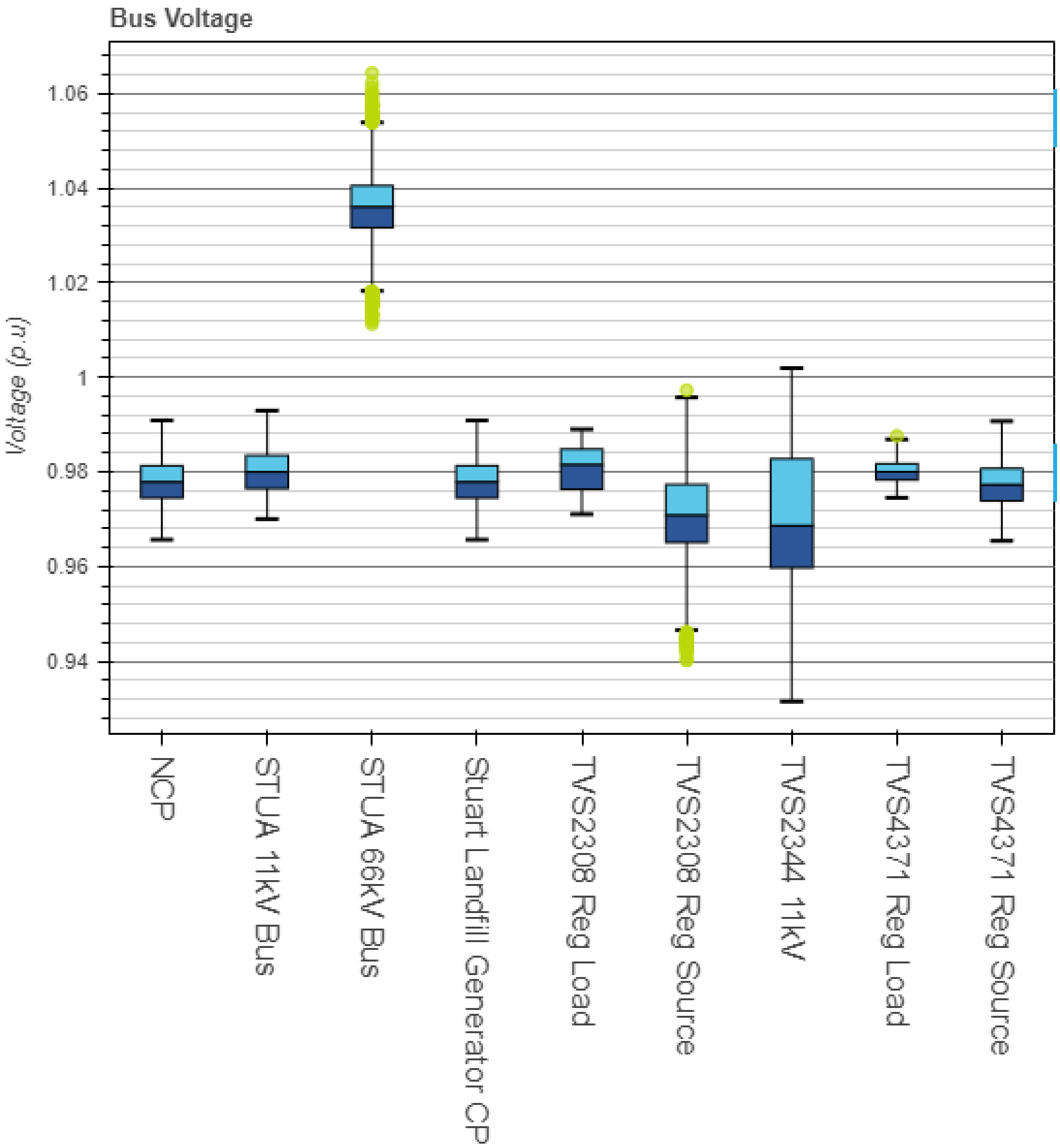

Figure 10 - Modelled voltages at key system nodes - Scenario 1 (Base Case)

Figure 11 displays a duration curve for the Stuart Landfill Gas Generator connection point voltage.

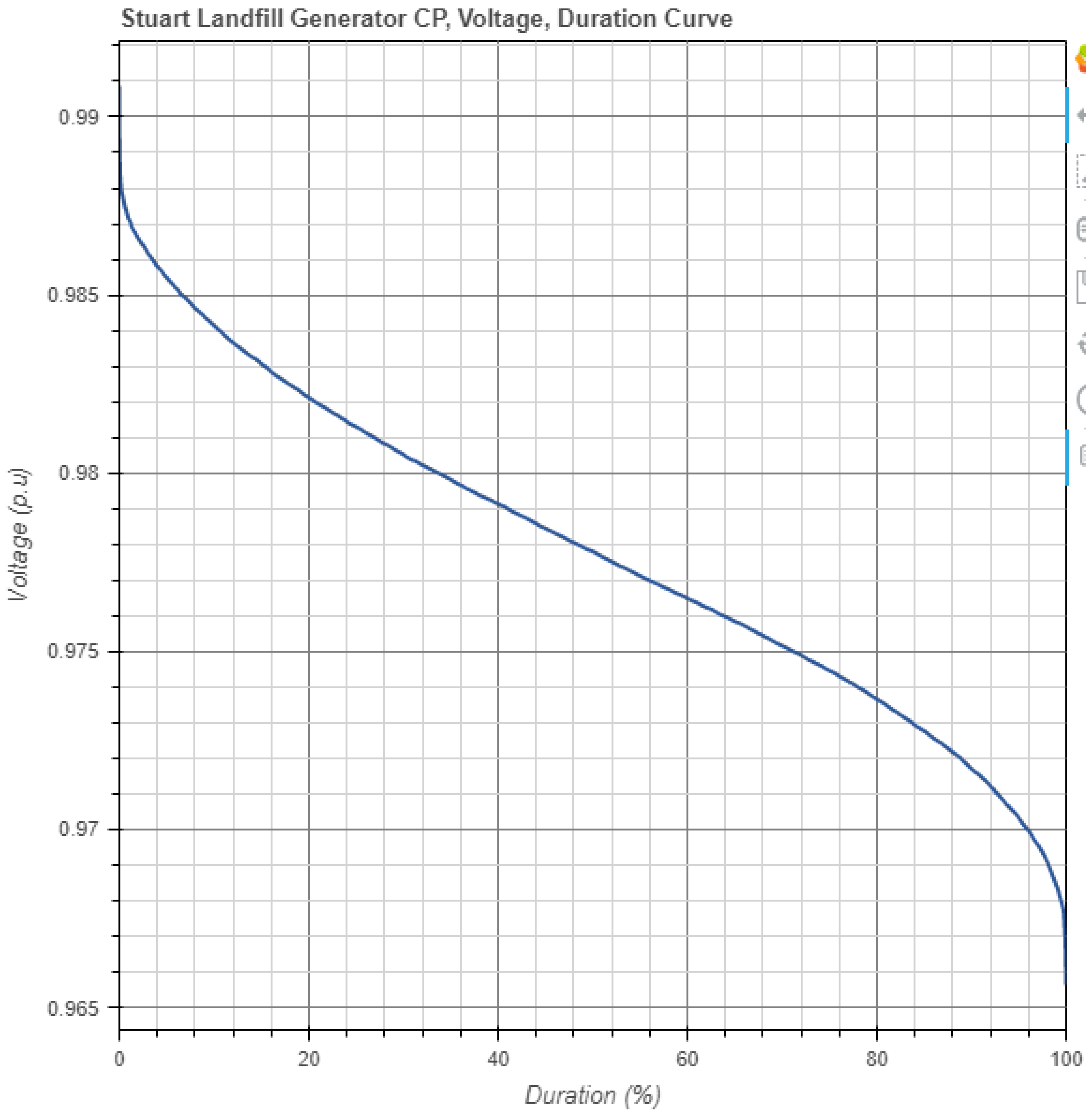

Figure 11 - Connection Point Voltage Duration Curve

8.2.1.2 Feeder Loading

Figure 12 represents a box-and-whisker plot (a statistical representation of the load throughout the year) of the expected loading of the ST-02 11kV feeder under normal conditions with the system in its current state without the proposed new generator connected. It is noted that the feeder utilisation is acceptable.

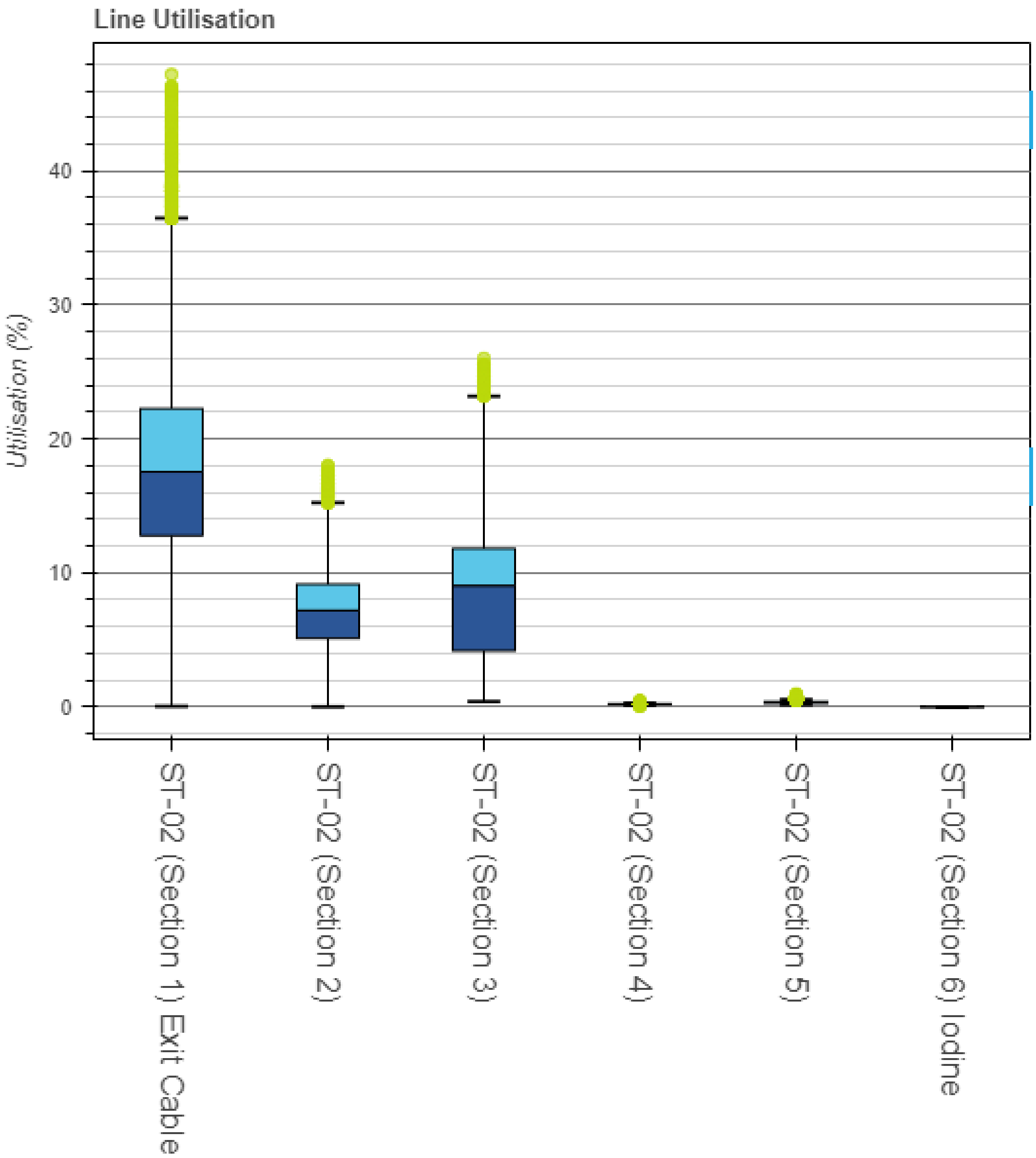

Figure 12 - Existing ST-02 11kV feeder utilisation

8.2.1.3 Transformer Loading

Figure 13 represents a box-and-whisker plot (a statistical representation of the load throughout the year) of the expected loading of the 66/11kV power transformers at Stuart Substation under normal conditions with the system in its current state without the proposed new generator connected. The Stuart Substation 11kV bus is operated normally open therefore there is no sharing of load.

It is noted that the transformer utilisation is acceptable.

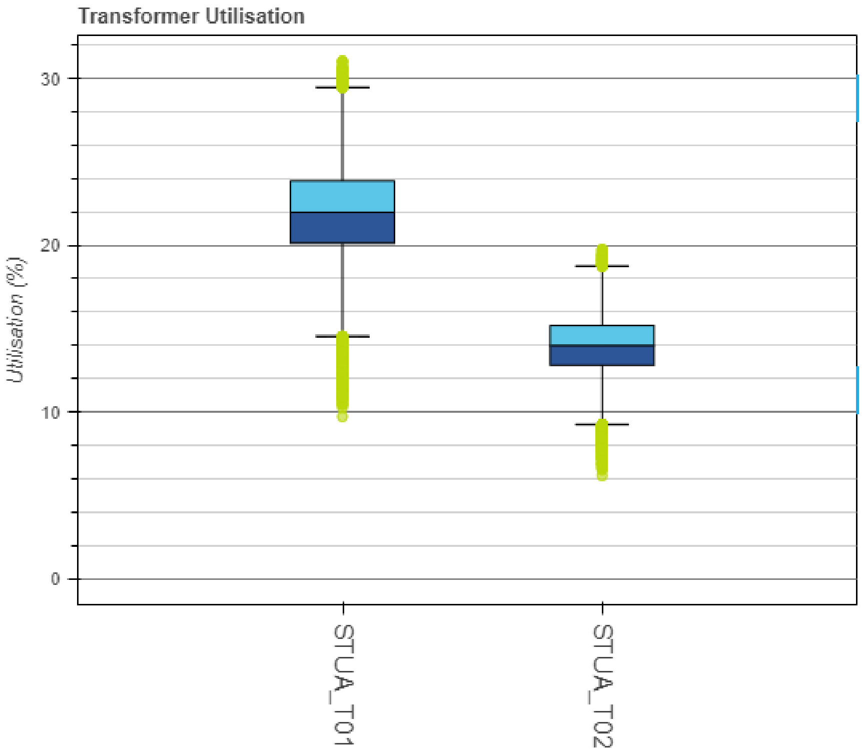

Figure 13 - Existing Utilisation of Stuart 66/11kV (STUA) Substation Transformers

8.2.1.4 Voltage Regulation & Transformer Tapping

Figure 14 shows the expected tap normalised frequency for the Stuart 66/11kV (STUA) Substation transformers. It can be seen from Figure 14 that the Stuart Substation transformers are anticipated to reach the maximum buck tap position, with STUA T1 and T2 on tap 1 for approximately 3% of the time in a year without the proposed new generator.

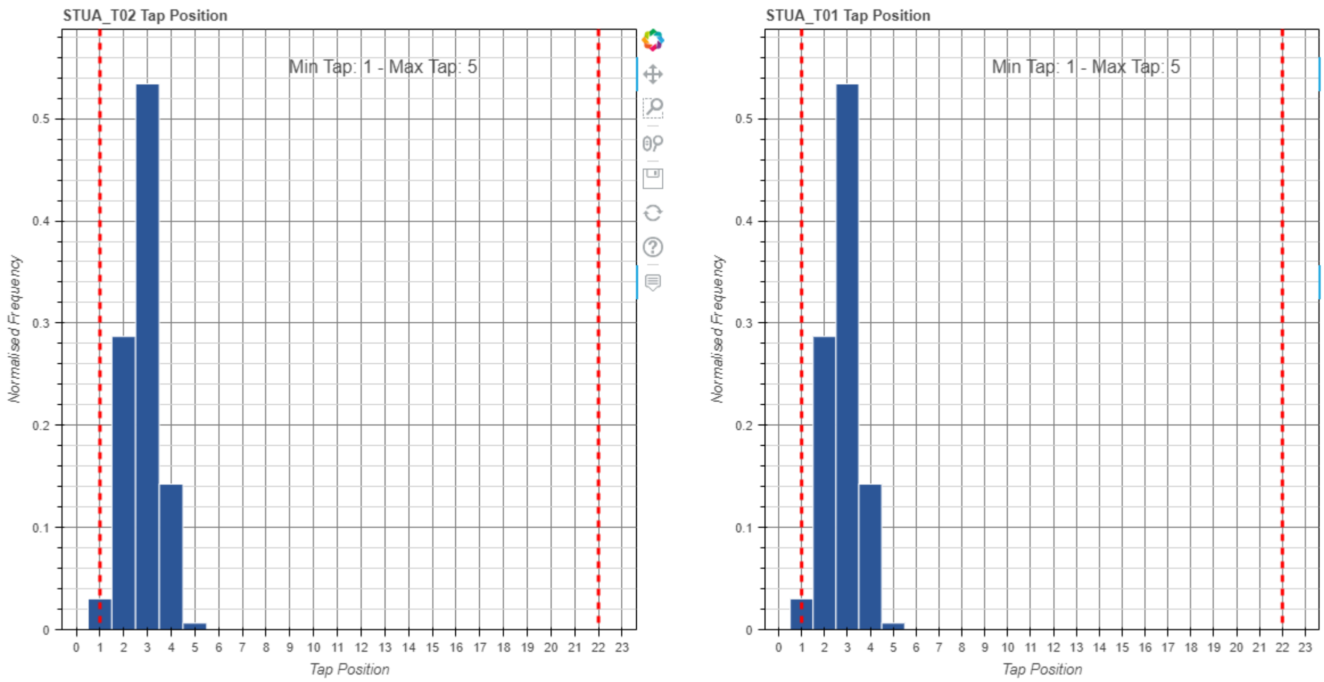

Figure 14 - Stuart 66/11kV (STUA) Substation Transformer Tap Position

Figure 15 shows the expected tap normalised frequency for the TVS4371 and TVS2308 voltage regulators. It can be seen from Figure 15 that the voltage regulators are not anticipated to reach the maximum buck tap position or the maximum boost tap position without the proposed new generator.

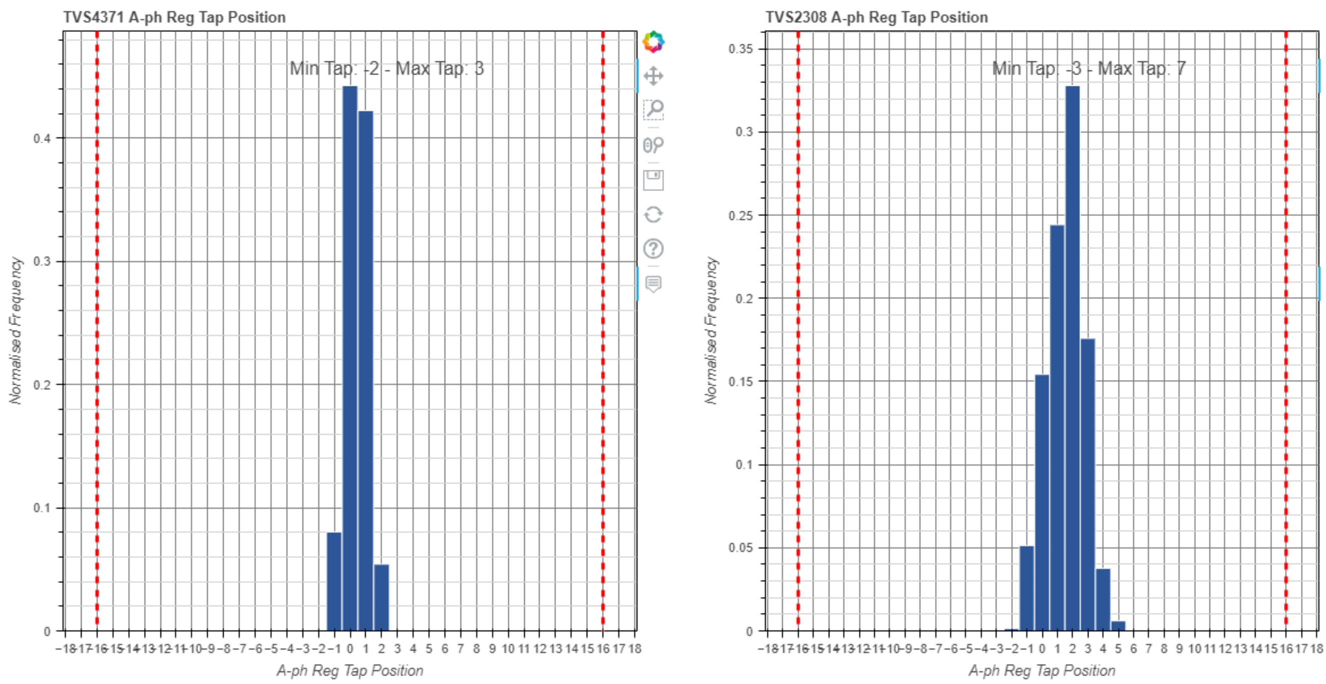

Figure 15 - Voltage Regulator Tap Position

8.2.2 Scenario 2 – System Normal with Generator in Service

This scenario involved investigating the operating state of the system in its normal state with the proposed new generator in service.

For this scenario, the Stuart Landfill Gas Generator is exporting their full requested export of 1.11 MW and operating in voltage control mode, utilising 4% droop, controlling the 11kV connection point to a set-point of 0.98p.u.

8.2.2.1 System Voltages

Figure 16 presents the range of voltages at each key system node with the proposed new generator in service. The 11kV bus voltage at Stuart 66/11kV (STUA) Substation is being regulated between 0.97 p.u. – 0.992 p.u. The proposed generator connection point has a modelled voltage range of 0.974 p.u. – 0.992 p.u. with an average voltage of 0.983 p.u.

The steady state voltage for the other customers on the ST-02 11kV feeder is able to be maintained within the allowable voltage range of 230V +10%/ 6% as legislated in the *Queensland Electricity Regulation*.

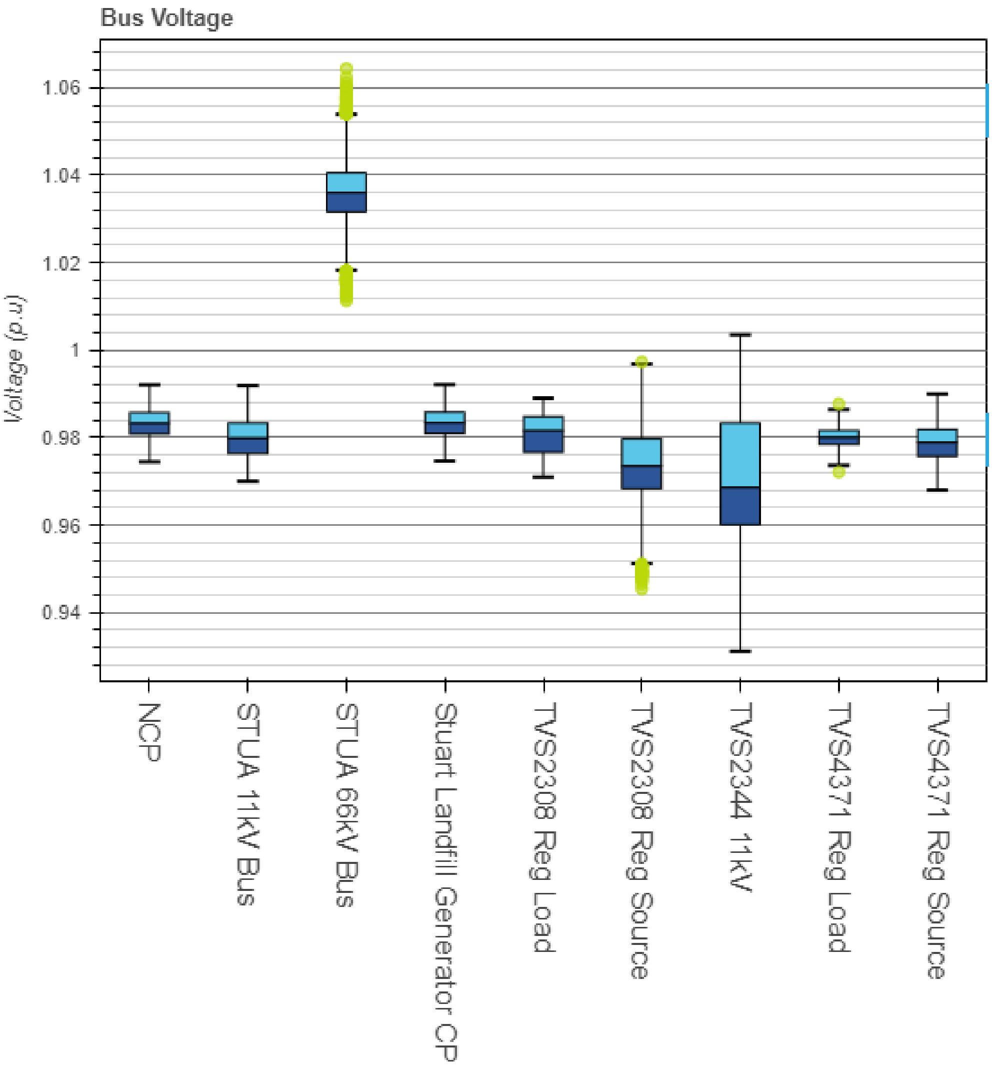

Figure 16 - Modelled voltages at key system nodes - Scenario 2 (Generator in Service)

Planning Report: Technical Assessment for Site STUART LANDFILL GAS GENERATOR

Figure 17 displays a duration curve for the Stuart Landfill Gas Generator connection point voltage with the proposed new generator in service.

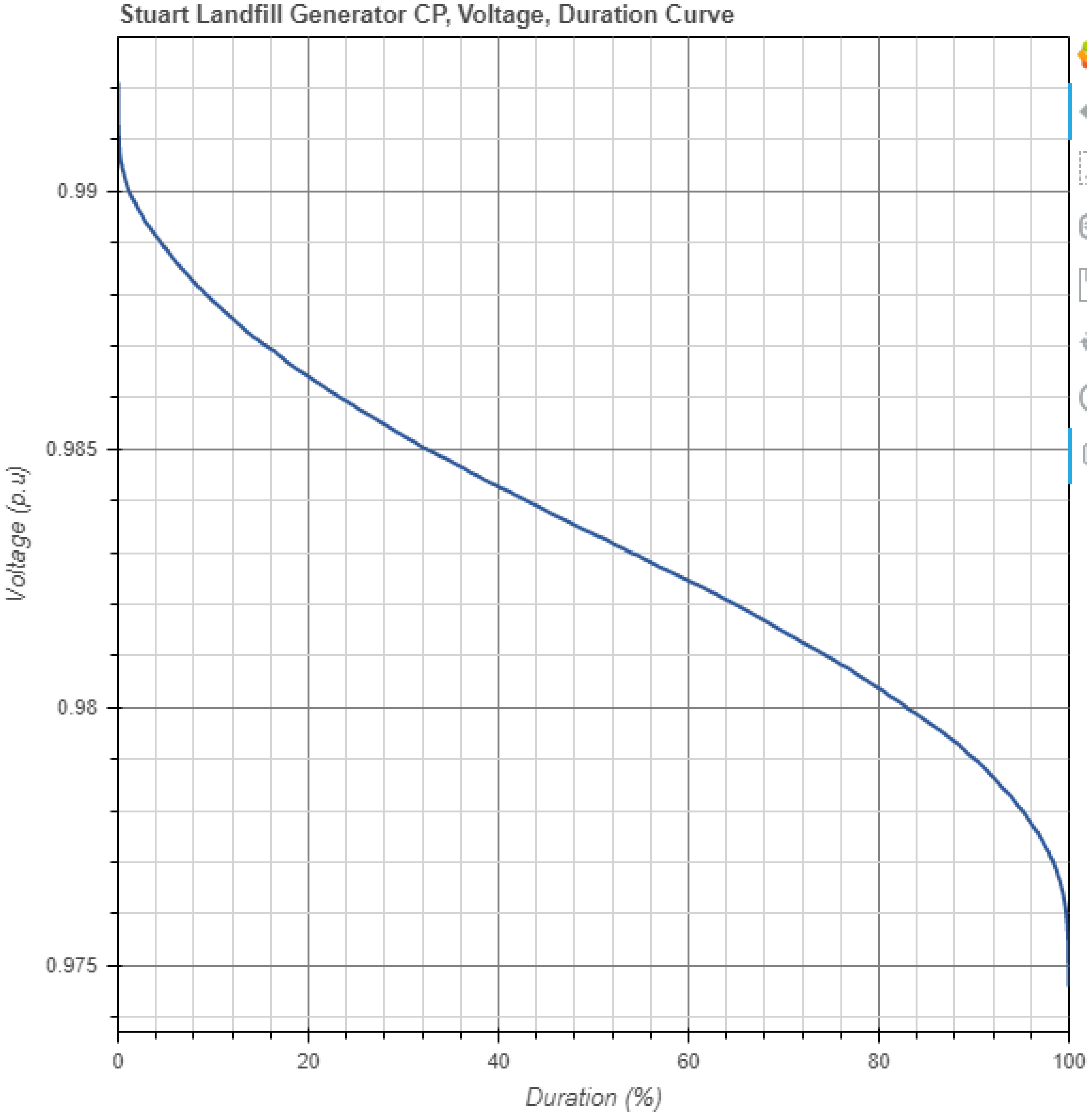

Figure 17 - Connection Point Voltage Duration Curve - Scenario 2 (Generator in Service)

8.2.2.2 Reactive Response

The reactive response of the Stuart Landfill Gas Generator is presented in correlation with the active power output in Figure 18, as a duration curve throughout the quasi-dynamic study in Figure 19 and by time of day in Figure 20.

From review of these figures it is noted that the reactive power output is close to the maximum the generating system is capable of outputting.

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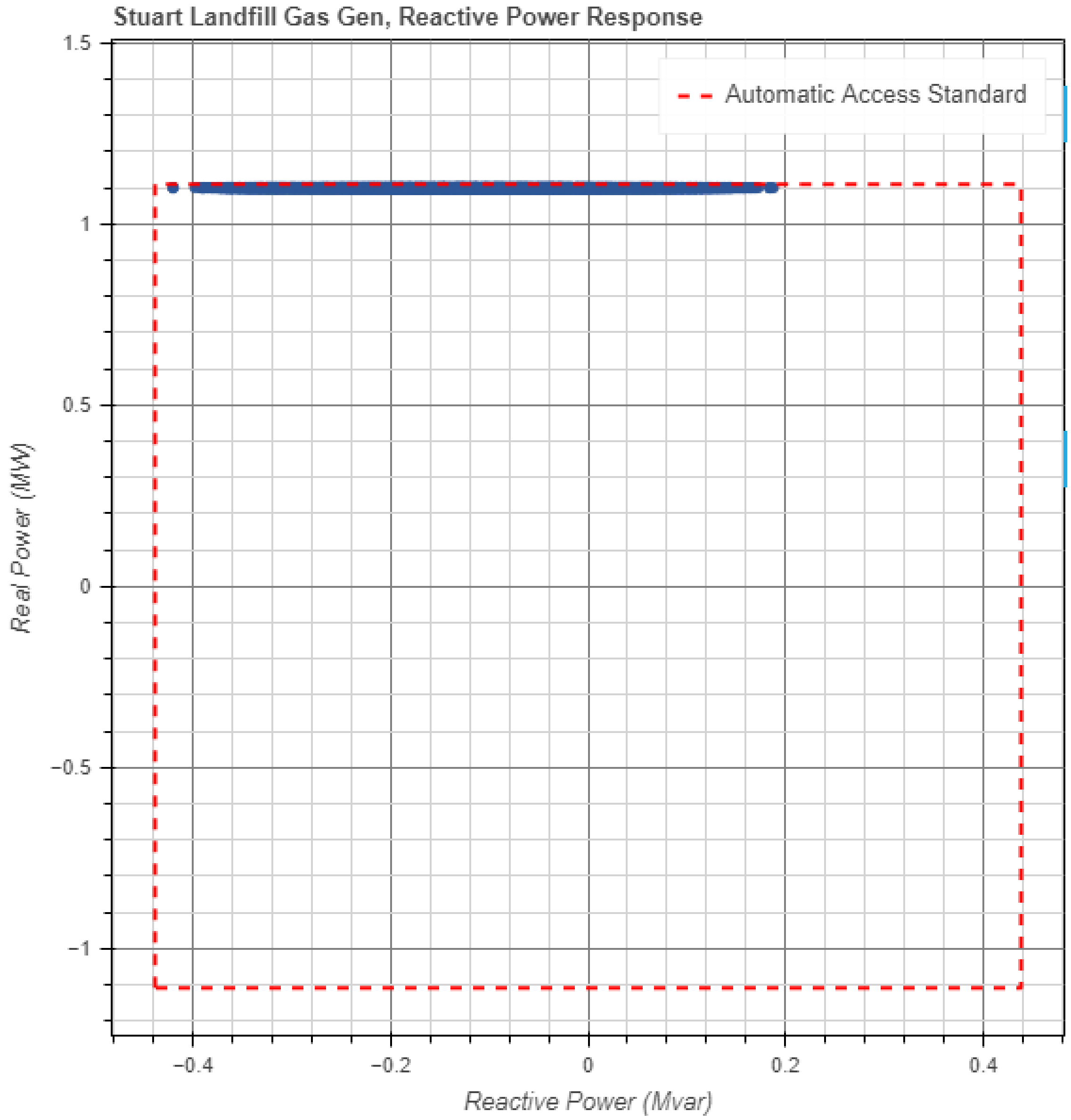

Figure 18 - Anticipated Reactive Power Requirement

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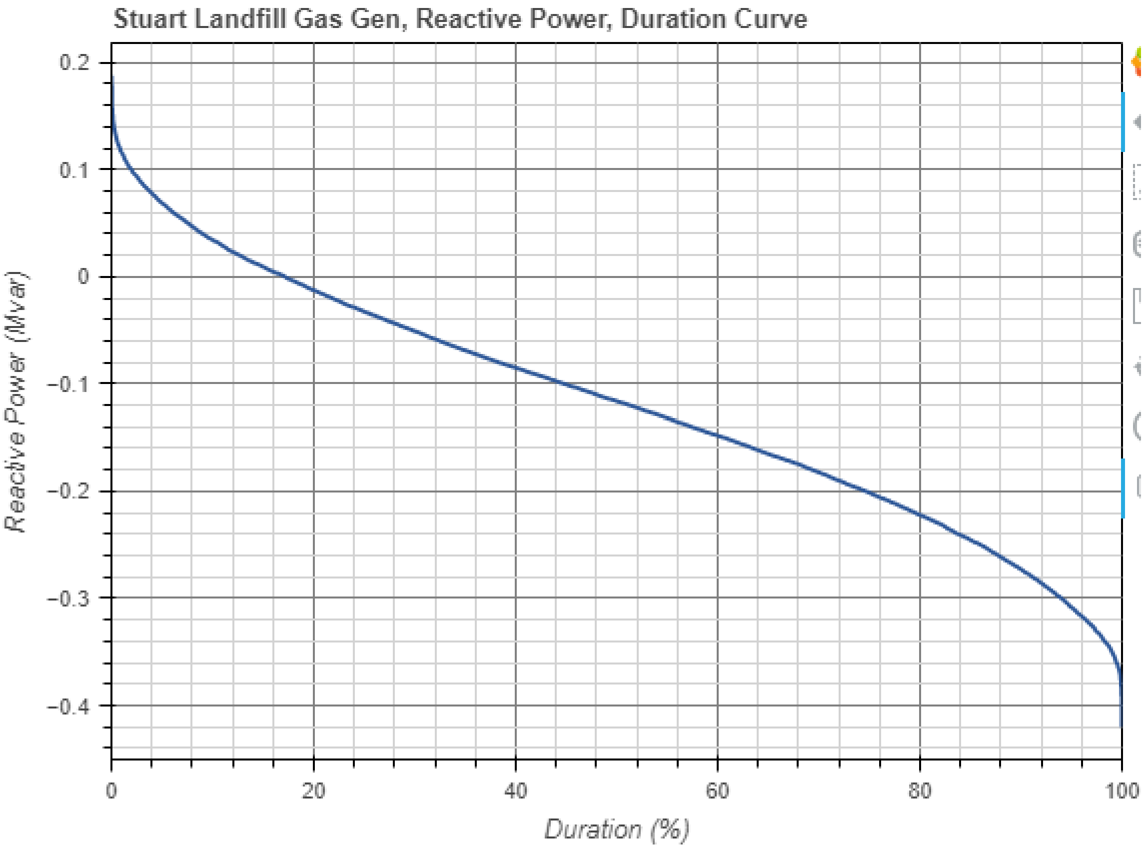

Figure 19 - Reactive Power Load Duration Curve

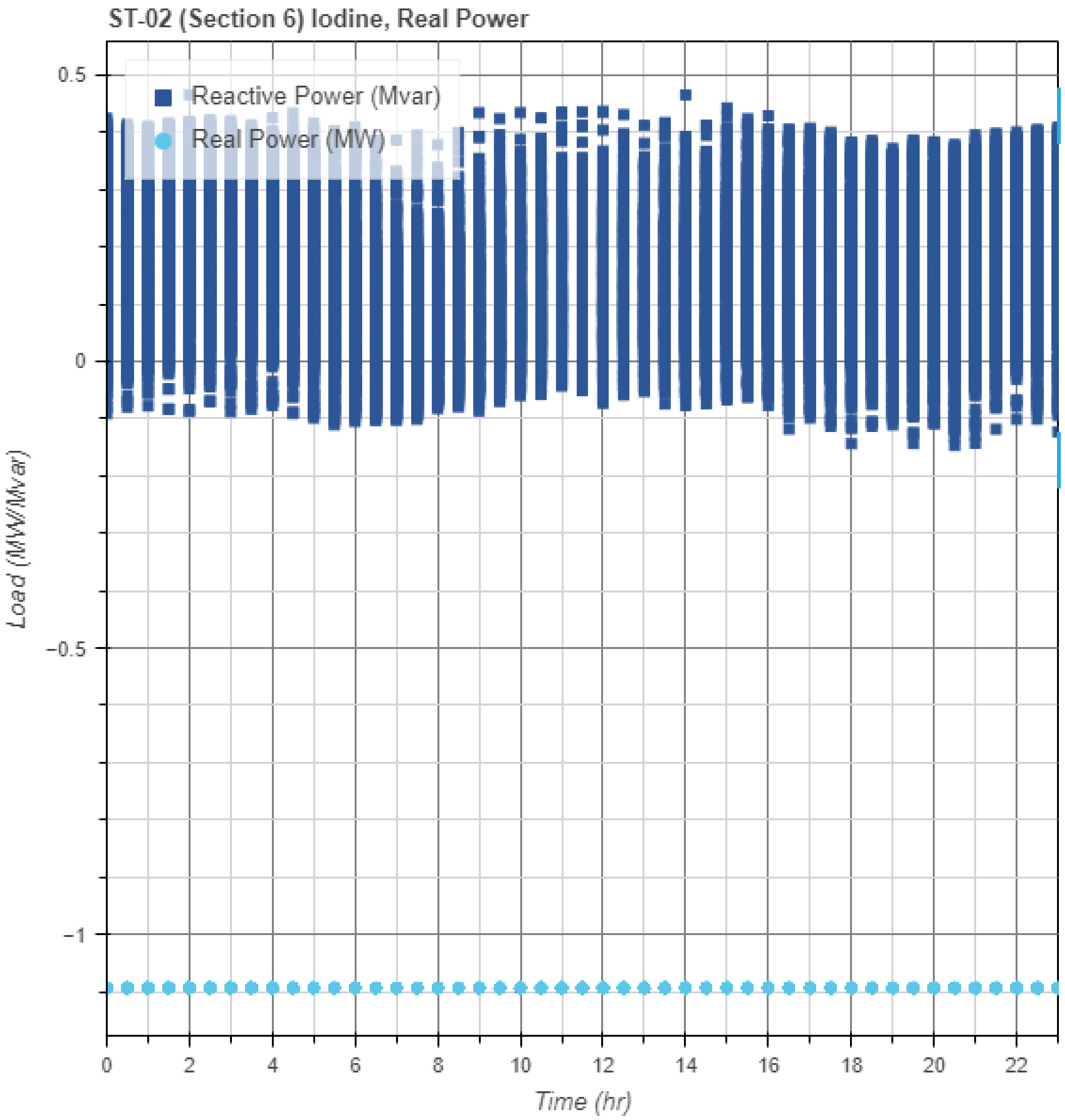

Figure 20 - Anticipated Reactive Power Requirement (Time of Day)

8.2.2.3 Feeder Loading

Figure 21 represents a box-and-whisker plot (a statistical representation of the load throughout the year) of the expected loading under normal conditions with the Stuart Landfill Gas Generator operating at full export of 1110 kW. It is noted that feeder utilisation on all sections of the ST-02 11 kV feeder is acceptable.

Planning Report: Technical Assessment for Site STUART LANDFILL GAS GENERATOR

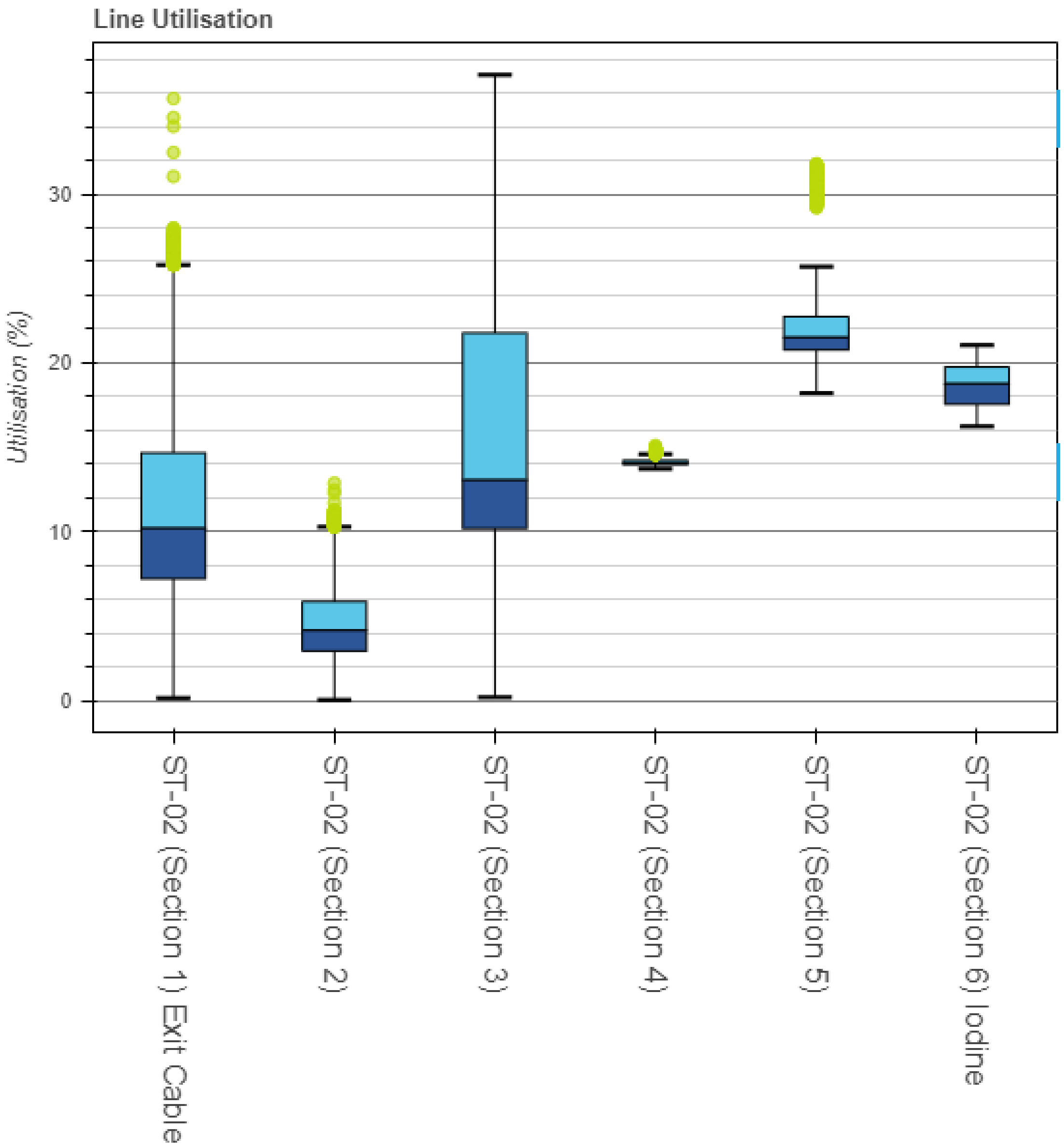

Figure 21 - Anticipated ST-02 feeder utilisation

8.2.2.4 Transformer Loading

Figure 22 represents a box-and-whisker plot (a statistical representation of the load throughout the year) of the expected loading of the 66/11kV power transformers at Stuart Substation under normal conditions with the system in its normal conditions with the Stuart Landfill Gas Generator operating at full export of 1110 kW. The Stuart Substation 11kV bus is operated normally open therefore there is no sharing of load.

It is noted that the transformer utilisation is acceptable.

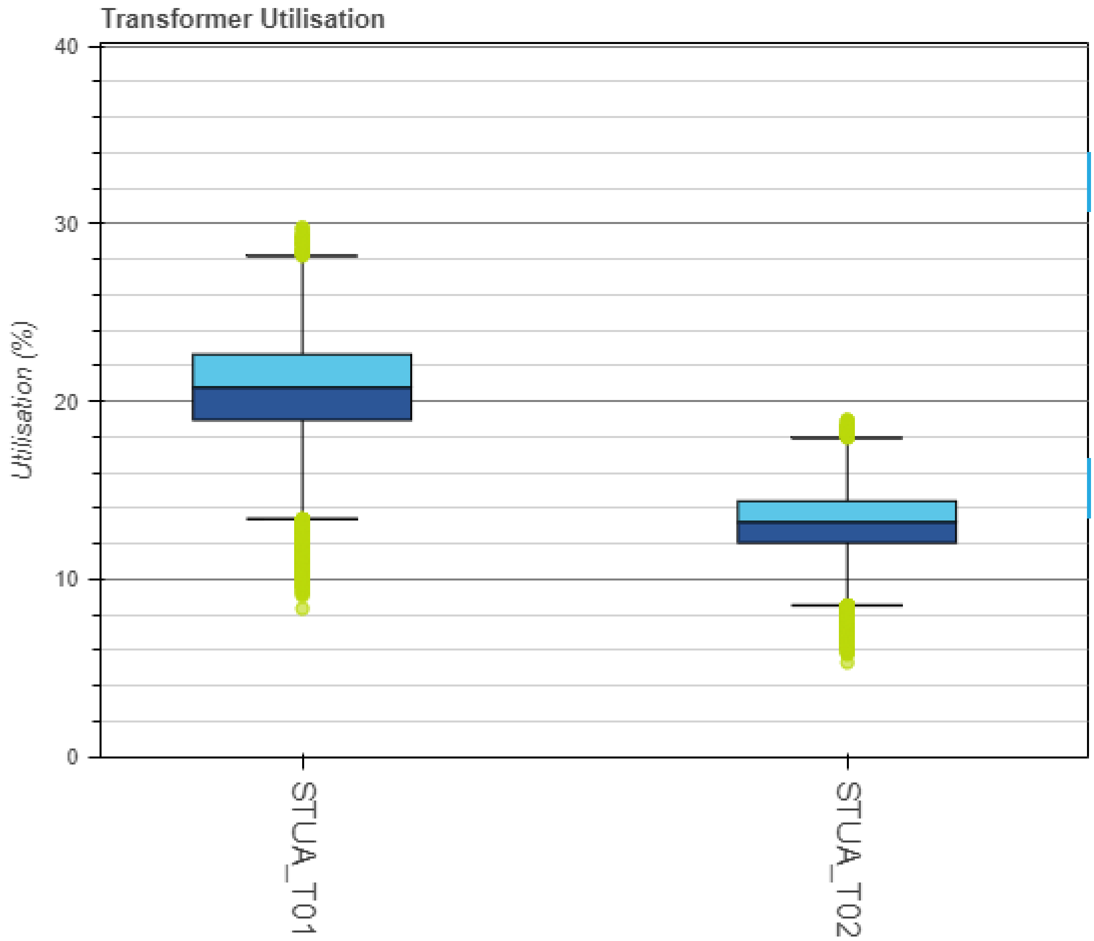

Figure 22 - Anticipated Utilisation of Stuart 66/11kV (STUA) Substation Transformers

8.2.2.5 Voltage Regulation & Transformer Tapping

Figure 23 shows the expected tap normalised frequency for the Stuart 66/11kV (STUA) Substation transformers. It can be seen from Figure 23 that the Stuart Substation transformers are anticipated to reach the maximum buck tap position, with STUA T1 and T2 on tap 1 for approximately 2% of the time in a year with the proposed new generator operating in voltage control.

Planning Report: Technical Assessment for Site STUART LANDFILL GAS GENERATOR

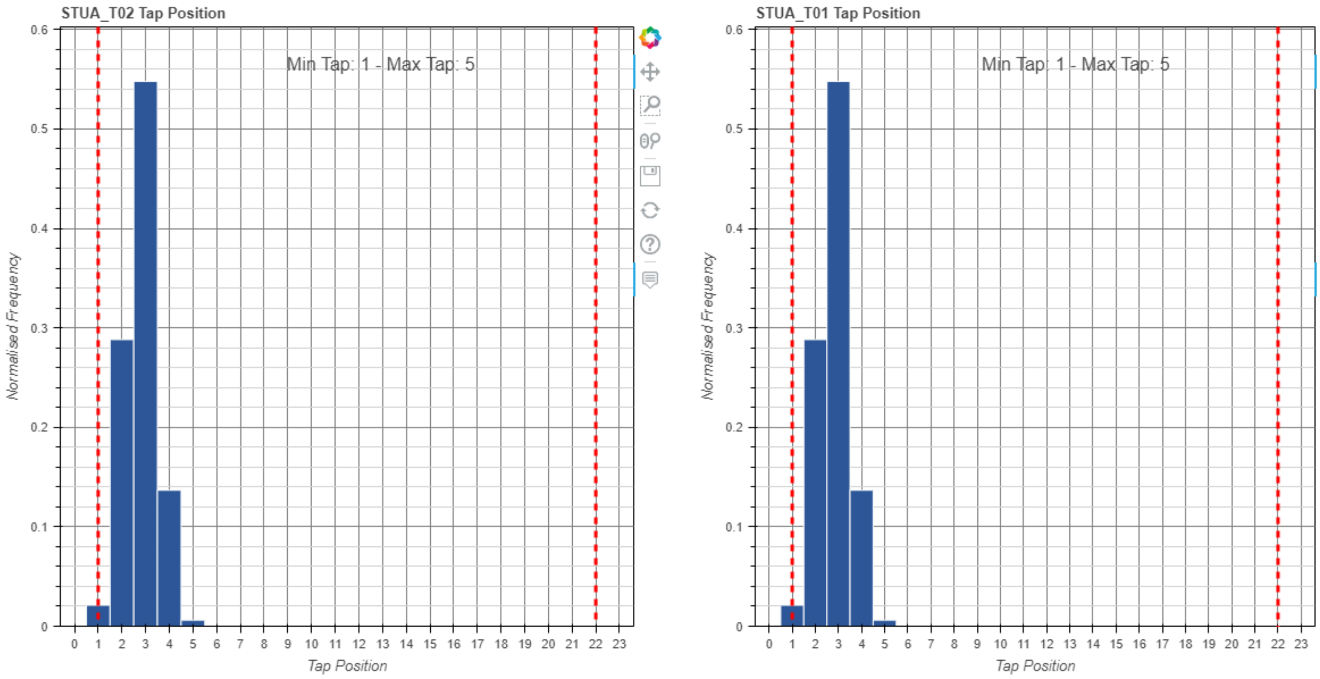

Figure 23 - Anticipated Stuart 66/11kV (STUA) Substation Transformer Tap Position

Figure 24 shows the expected tap normalised frequency for the TVS4371 and TVS2308 voltage regulators. It can be seen from Figure 24 that the voltage regulators are not anticipated to reach the maximum buck tap position or the maximum boost tap position with the proposed new generator.

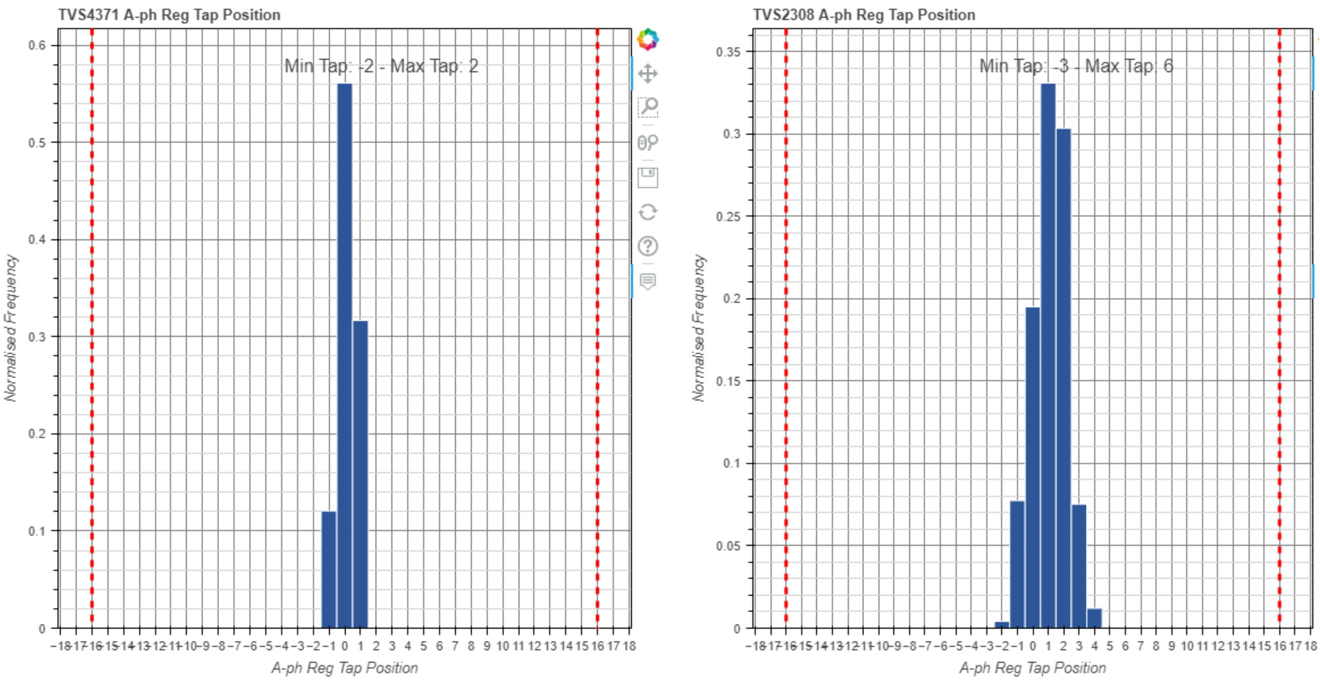

Figure 24 - Anticipated Voltage Regulator Tap Position

8.2.2.6 Generator rejection studies

A quasi-dynamic generator rejection study was performed to identify the impact on the Stuart Landfill Gas Generator connection point, network coupling point, Stuart 66/11kV (STUA) Substation 11 kV bus, and surrounding supply points in the event of all generation being lost at the Stuart Landfill Gas Generator connection point.

In regards to voltage fluctuations, the National Electricity Rules has a Queensland jurisdictional derogation S9.37.12 that replaces S5.1.5. The Voltage Fluctuation limits applicable for customers on the *Ergon Energy* network would be as per the allocated percentage of the threshold of irritability set out in Figure 1 of Australian Standard AS2279, Part 4.

For events that are generally unlikely to occur each day, such as a complete loss of generation at the connection point, the customer would need to ensure that the voltage change at the Point of Common Coupling (PCC) is not greater than 5%.

A quasi-dynamic generator rejection study was performed, and modelling shows that no voltage steps of greater than 5% were encountered within the distribution network in the event of a generator disconnection.

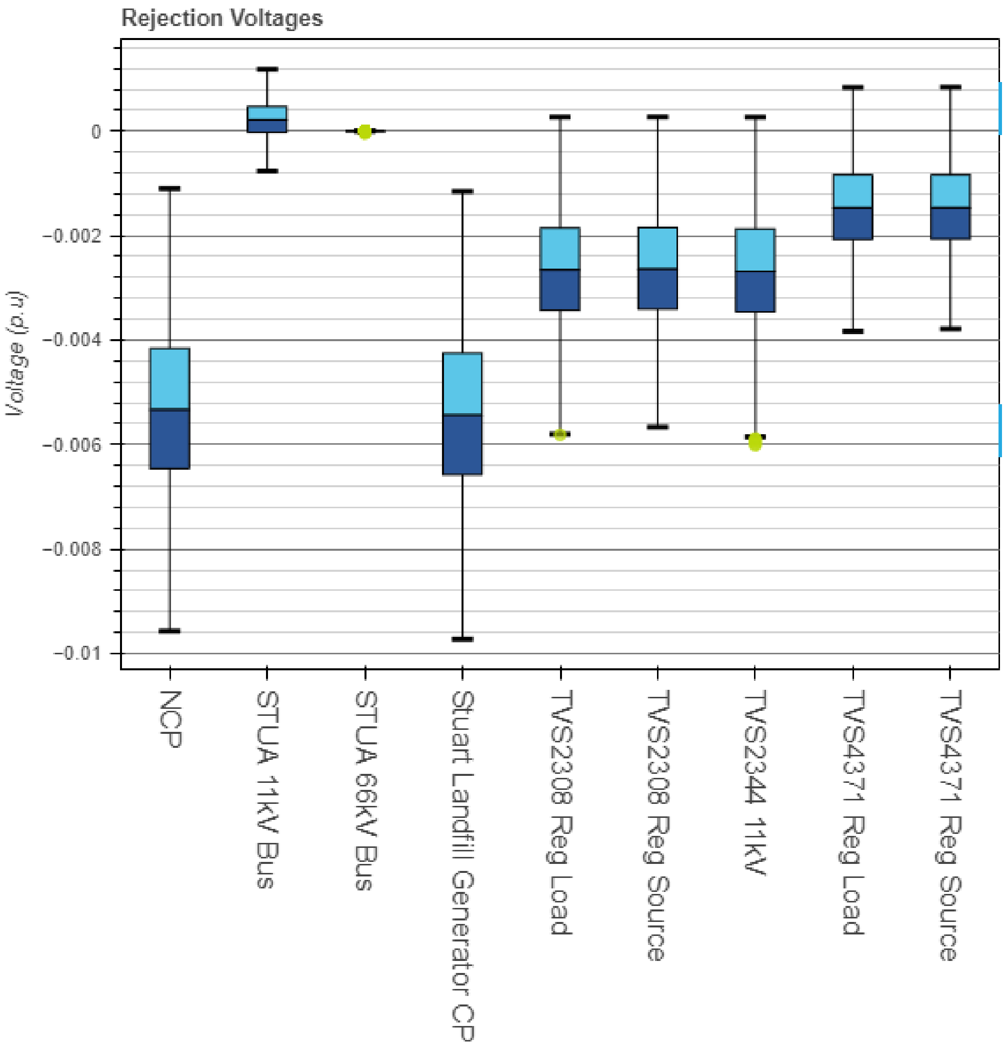

Figure 25- Voltage Step on Loss of Generation

8.3 Power System Modelling Summary

1387 kVA 11 kV ST-02 Bruce Highway 11kV Feeder Connection					
Parameter	**EG Status**	**Pass/ Fail**	**Result**	**Conclusion**	**Recommendations**
Thermal Limitation	Exporting	Pass	No anticipated overloading	No Action Required	Nil
Steady State Voltage Impact	Exporting	Pass	Steady state voltages within the acceptable limits.	Voltage control recommended	EG is to operate in voltage control mode, utilising 4% droop, controlling the 11kV connection point to a set-point of 0.98p.u
Impact on transformer tapping	Exporting	Pass	The Stuart Substation power transformer tapping range is anticipated to be hitting the maximum buck tap however the 11kV bus voltage is anticipated to stay within the required bandwidth	No Action Required	Nil
Impact on voltage regulator tapping	Exporting	Pass	The TVS4371 and TVS2308 regulator tapping range is anticipated to be slightly decreased	No Action Required	Nil
Loss of Stuart Landfill Gas Generator	Exporting	Pass	The worst-case voltage step is anticipated to be less than 1%	No Action Required	Nil

8.4 Modelling Conclusion

Based on the results shown in Section 8.2 and summarised in Section 8.3 it can be seen that the connection of the Stuart Landfill Gas Generator to the ST-02 11 kV feeder can be facilitated.

The power system modelling has not identified any thermal or voltage constraints on the distribution network as a result of the proposed new generator, and the voltage steps upon loss of the connection point were acceptable.

It can also be seen in the results that based on the Automatic Access Standard for reactive power capability the Stuart Landfill Gas Generator is able to support the proposed 0.98p.u. voltage setpoint with 4% droop at the Connection Point when exporting at 1110 kW.

8.5 Fault levels

The fault currents that *we* nominate at the proposed *connection point,* for the proposed network configuration are set out in the following table:

Table 4 – Prospective 11 kV *connection point* fault levels

Network Fault Current Contribution at Connection Point (kA)				Impedance (Ohms)					
				R_1	X_1	R_2	X_2	R_0	X_0
Existing *distribution system –* system normal	3ϕ	Maximum	3.937 kA	0.7151	1.6239	0.7151	1.6234	1.2884	5.6072
	1ϕ-g		2.263 kA						
	3ϕ	Minimum	3.078 kA	1.1088	1.7402	1.1089	1.7424	1.6675	5.6406
	1ϕ-g		1.921 kA						

Notes:

1. The above fault levels are based on a 1.1 p.u. driving voltage for maximum faults and 1.0 for minimum faults assuming existing network configuration and may change in future.
2. Bolted 3ϕ and 1ϕ-g faults at the nominated *connection point*.
3. Fault levels provided are for the recommended *connection* option.

Based on the impedance data provided by the *Connection Applicant*, the prospective fault current contribution has been calculated. It has been assumed that the generator fault level contribution is inversely proportional to the generator impedances, the generator impedance has been reduced by 30% to simulate a 30% increase in fault level contribution as per Table 20 of AS60034-1. This is shown in Table 5. Hence, it has been modelled that the proposed *generating system* will have a prospective fault current at the *connection point* for the recommended option of approximately:

a) 3ϕ = 0.544 kA
b) 1ϕ-g = 0.195 kA

Table 5 - Generator Impedance

Parameter	Value
Nominal Voltage	415 V
Rated Apparent Power	1387 kVA

Rated Power	1110 kW
Power Factor	0.8
Sub-transient Reactance (X"d)	0.1049 p.u.
Transient Reactance (X'd)	0.1551 p.u.
Synchronous Reactance (Xd)	1.9050 p.u.
Negative Sequence (X_2)	0.1004 p.u.
Zero Sequence (X_0)	0.0057 p.u.
Stator Resistance	0.0107 p.u.

Based on the above fault current contributions at the *connection point*, the total prospective fault levels at the *connection point* are shown in Table 6 below.

Table 6 - Prospective total fault levels at the 11 kV *connection point*

Total Fault Current at Connection Point (kA)		
Existing *distribution system* with *generating system connected*	3ϕ	4.460 kA
	1ϕ-g	2.367 kA

Table 7 sets out a list of typically constraining plant fault level ratings, based on *our* existing procurement policy. These are the target fault levels that *we* attempt to adhere to in most cases.

Table 7 – Fault levels from *our* procurement policy

Voltage	New Installation
132/110 kV	40 kA/1 s
66 kV	25 kA/3 s
33 kV	25 kA/3 s
22 kV	20 - 25 kA/3 s
11 kV	20 - 25 kA/3 s

Even though the prospective fault levels at the proposed *connection point* as provided in Table 4 are relatively low, *we* cannot predict what these fault levels may increase to in the future. Therefore, it may be prudent for *you* to specify *your* plant in accordance with Table 7.

8.6 System Strength and Stability Considerations

Recent increased levels of penetration of generation within the power system are impacting on power system stability. Consequently, changes have been made to the NER to address this issue and maintain the stability of the power system going forward. *You* should make *yourself* familiar with these changes and the relevant obligations on generating system proponents.

An assessment has been made to determine the system strength at *your connection point*. This involves consideration of relevant fault levels and the short circuit ratio, as these metrics correlate with system strength (that is, weaker power systems have lower fault levels and lower short circuit ratios, typically less than 5). Stable operation of asynchronous generators is increasingly an issue as the short circuit ratio decreases below 3.

Short Circuit Ratio is calculated with the following formula:

$$SCR = \frac{S_{CMVA}}{P_{max}}$$

Where S_{CMVA} is the minimum fault contribution in MVA of the studied bus and P_{max} is the maximum inverter capacity of the proposed power electronic converter generators

Nearby asynchronous generating systems can interact with each other. To determine whether this is likely, a calculation of the Weighted Short Circuit Ratio is made, using the following formula:

$$WSCR = \frac{\sum_i^N S_{SCMVAi} * P_{RMWi}}{(\sum_i^N P_{RMWi})^2}$$

Where S_{CMVAi} is the minimum fault contribution in MVA of the studied bus and P_{RMWi} is the P_{max} of all nearby power electronic converter generators

An assessment has been made with respect to your system. This *generating system* has been classified as a Class A1 system.

This means, the following modelling requirements apply:

Class A1, EMT model not required

This is detailed further in section 9.2 below.

8.7 Harmonic and Flicker Allocation

Harmonic emission levels have been assessed in accordance with Section 8 of SA/SNZ TS IEC 61000.3.6.

Table 8 - Harmonic Allocation for 1387 kVA Stuart Landfill Gas Generator

h	V%	h	V%
2	0.10%	22	0.10%
3	0.10%	23	0.13%
4	0.10%	24	0.10%
5	0.28%	25	0.12%
6	0.10%	26	0.10%
7	0.21%	27	0.10%
8	0.10%	28	0.10%
9	0.10%	29	0.10%
10	0.10%	30	0.10%
11	0.39%	31	0.10%
12	0.10%	32	0.10%
13	0.31%	33	0.10%
14	0.10%	34	0.10%

15	0.10%	35	0.10%
16	0.10%	36	0.10%
17	0.19%	37	0.10%
18	0.10%	38	0.10%
19	0.17%	39	0.10%
20	0.10%	40	0.10%
21	0.10%	THD	0.37%

Flicker allocations have been assessed in accordance with Section 8 of the Technical Report IEC61000.3.7.2012

Table 9 - Flicker Allocation for 1387 kVA Stuart Landfill Gas Generator

Flicker Allocation	
Pst	0.35
Plt	0.25

9 TECHNICAL DATA TO BE INCLUDED WITH THE APPLICATION TO CONNECT

9.1 System Documentation

The Applicant is required to provide with the connection Application:

- Single line diagrams, showing the connection arrangement and generating system clearly showing the connection point including primary electrical SLD
  - This shall include switching arrangements for each generating unit, including demonstration of break-before-make units or bumpless make-before-break switch arrangements, if applicable
- Datasheets of rotating machines, relays, panels, and other primary equipment
- Documentation that demonstrates compliance with Energy Queensland Standard STNW1175 and relevant equipment standards (e.g., AS/NZS4777.2, AS/NZS IEC 62116, AS/NZS IEC 60947.6.1 as relevant)
- A report detailing all control system settings to be applied to the inverter or generator control system on site and justification for those settings
  - Inclusive of generator behaviour in the case of internal communications systems failure
- Draft Non Registered Generator Performance Standard
- Modelling requirements as detailed below, with Information provided by the inverter manufacturers, including confirmation of validity of models at low short circuit ratio
- For the active and reactive power control systems a diagram showing the location of the relevant measurement locations.
- A report detailing the Voltage Control Strategy of the site should be provided. This should include details of the following items where relevant; reactive power control strategy, active

power control strategy, transformer tap changer control strategy, switched shunt control strategy.

- Communications fail control documentation. Guidance is provided in the AEMO Communication System Failure Guidelines

Refer to the Application Checklist for further details – Class A1

9.2 Modelling Requirements

The Applicant is required to carry out modelling and provide system models in accordance with Energy Queensland Standard STNW1175 as required for a Class A1 System. For more information, refer to our Modelling Information Factsheet.

For a Class A1 system, a system model is not required.

It is a requirement that there will be no on-site tuning of any EG system parameters that impact dynamic EG unit performance, or remotely adjust any EG system parameters, without prior written approval from Ergon Energy.

10 GLOSSARY OF TERMS

Abbreviation	Term
A	Amps
ACS	Alternative Control Services
AD	Authorised Demand
AFLC	Audio Frequency Load Control
AP	Approved Plan
AS	Australian Standard
AVR	Automated Voltage Regulator
CAPEX	Capital Expenditure
CARE	Cyclone Area Reliability Enhancements
CAW	Contract Awarded
CB	Circuit Breaker
CCM	Construction Commenced
CICW	Customer Initiated Construction Works
CP	Connection Point
CT	Current Transformer
CVT	Capacitor Type Voltage Transformer
ECC	Emergency Cyclic Capacity
FACTS	Flexible AC Transmission System
FCA	First Capacity Available
GSM	Global System for Mobile Communications
HV	High Voltage
IDR	Implementation Design Released
IED	Intelligent Electronic Device
IP	Internet Protocol
IRC	Investment Review Committee
kA	Kilo Amp
kV	Kilovolt
kVArh	Kilovolt Amps Reactive Hours
kW	Kilowatt
kWh	Kilowatt-hour

Abbreviation	Term
LCF	Local Control Facility
LED	Light Emitting Diode
LMVP	Type of VACUUM Type CB
LTEC	Long Term Emergency Cyclic
MDP	Meter Data Provider
MiCOM	Type of Brand/Model For Protection Relays
MSP	Message Switching Protocol
MW	Megawatt
NATA	National Association of Testing Authorities
NCC	Normal Cyclic Capacity
NCR	Normal Cyclic Rating
NER	National Electricity Rules
NIRC	Network Investment Review Committee
OCN	Operational Communications Network
OES	Operational Engineering Service
OLTC	Online Tap Changer
OPEX	Operating Expenditure
OPGW	Optical Ground Wire
OTD	Operational Technology Deployment
PCO	Project Close Out
PDA	Protection Design Advice
PDH	Plesiosynchronous Digital Hierarchy
PIA	Project Initiation Advice
PoP	Plant Overload Protection
PSS	Project Scope Statement
QECM	Queensland Electricity Connection Manual
QEMM	Queensland Electricity Metering Manual
RAM	Regional Asset Management
RDAS	Remote Data Acquisition Server
RMS	Root Means Square
RTU	Remote Terminal Unit

Abbreviation	Term
RWH	Recommended Works Handover
RWR	Recommended Works Report
SCADA	Supervisory Control & Data Acquisition
SCCP	Single Circuit Concrete Pole
SCS	Standard Control Services
SDH	Synchronous Digital Hierarchy
SEL	Schweitzer Engineering Laboratories
SFU	Static Frequency Unit
SIRC	Strategic Investment Review Committee
SME	Subject Matter Experts
SP	Service Provider
STNW1174 Standard for LV EG Connections	STNW1174
STNW1175 Standard for High Voltage EG Connections	STNW1175
SWER	Single Wire Earth Return
TAPS	Transmission & Project Services
TCR	Thyristor Controlled Reactor
TSR	Technical Specification Released
V	Volt
VT	Voltage Transformer
WCO	Warranty Close Out
ZSS	Zone Substation Standard

11 APPENDIX A – LOCALITY MAP

11.1 Geographic area

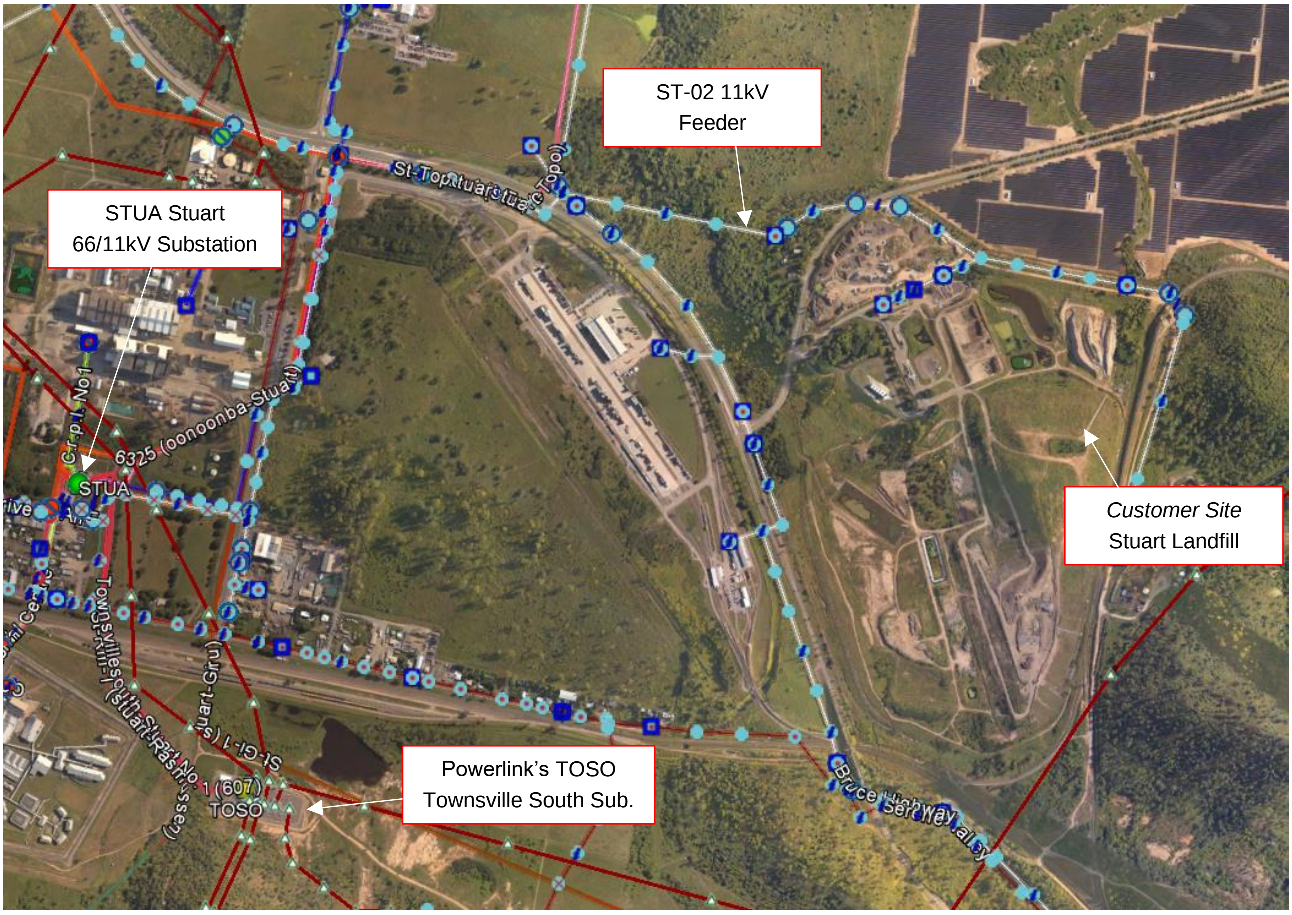

Figure 26 - Overview of Area

12 APPENDIX B – SINGLE LINE DIAGRAMS

12.1 Single line diagram of connection option 1

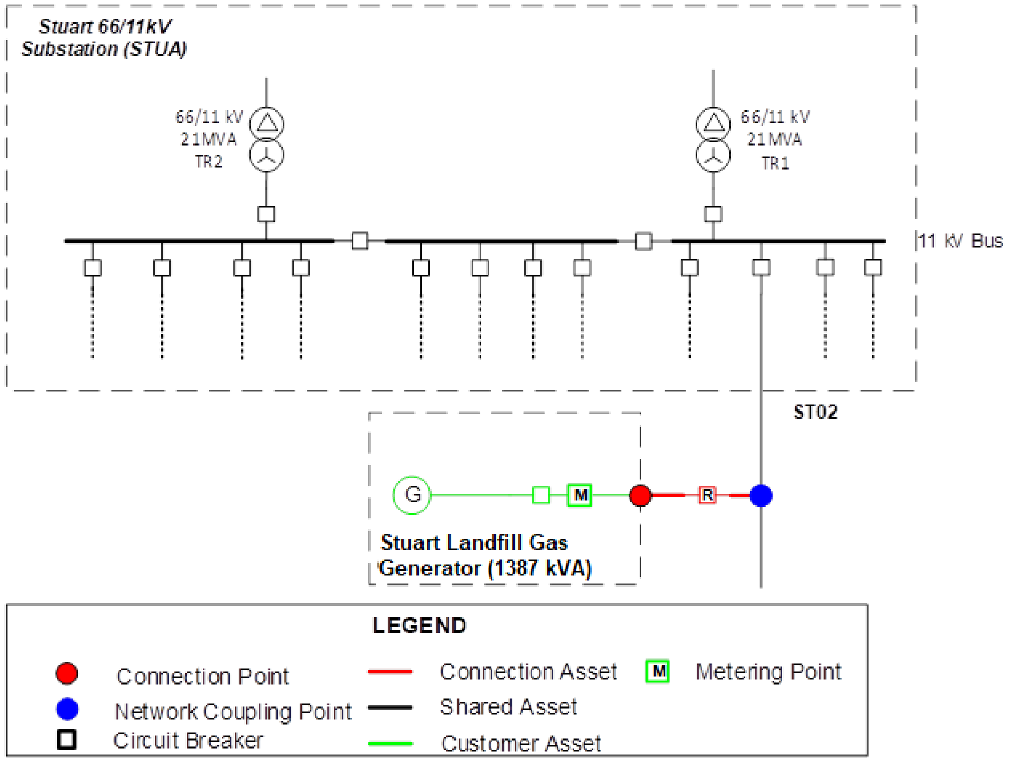

Figure 27 - Single Line diagram of Option 1